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THE TREATMENT OF RECTAL LYMPHOGRANULOMA BY EXCISION

REPORT OF SIX CASES OPERATED ON BY THE LOCKHART-MUMMERY PROCEDURE*

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THE symptoms observed in the anorectal syndrome of lymphogranuloma inguinale may be either local or general. The local phenomena are those associated with inflammatory swelling, ulceration, and obstructive narrowing. The outstanding general symptoms are loss of weight, secondary anemia, fever, and asthenia, while joint changes and toxic psychoses are occasionally seen.

In the usual run of cases with no general symptoms, palliative measures, such as graduated dilatation, serve to keep most patients in fit enough condition for all ordinary activities. For them hospitalization may be necessary from time to time for proctotomy and forcible dilatation under anesthesia. In a general hospital such patients are acceptable because of the short period of admission which they require. When, however, any case manifests general symptoms of any severity, the probable period of institutional care becomes considerably lengthened, a difficulty overcome in most communities by the provision of a "municipal" hospital, whose function it is to take care of chronic illness. Most of the unfavorable cases of anorectal syndrome, after having passed from one institution to another, find their way eventually to such a hospital and it is this type of case in this type of institution with which this paper is concerned.

*Since preparation of this paper four additional excisions have been performed. In all four cases, convalescence is proceeding satisfactorily but they are considered too recent to merit inclusion.

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After some little experience with these cases, it becomes increasingly plain that the usual maneuvers are totally inadequate for their care. The proctologist soon comes to realize that he is guilty of performing certain futilities, dilating strictures where little narrowing exists, excising fistulas far too complicated to excise, removing tags and inflammatory swellings that surely recur, attempting closure of rectovaginal defects impossible to close. Following each minor interference in any particular case, the general symptoms become more and more pronounced, the patient more and more intoxicated.

Some have sought to combat this sequence with colostomy alone, and in many cases this will suffice, especially if the lesion is purely obstructive and for one reason or another will not yield to dilatation. But when the general symptoms are progressive, which they frequently appear to be almost from the very initiation of the disease, colostomy no longer can be considered definitive treatment. Intoxication may continue until the patient succumbs to it or to some terminal infection. With the failure of colostomy often to do more than stem the invasion, it has been natural to seek something further and the possibilities of excision demand consideration.

The recent literature reveals very few references to excision and not much enthusiasm in its favor. Seemingly its only protagonist in the days before the Frei test was H. Hartmann,[1] who conservatively removed rectal strictures by a Whitehead type of operation. Of 34 operated upon by this method, 2 died and 32 were said to be cured. Two abdominoperineal excisions performed by the same author resulted in 1 death and 1 recovery.

Yeomans[2] in 1933 reported a solitary case of stricture excised twenty-three years previously by the perineal route with creation of a perineal anus. The patient was still leading an active life at the time of the report.

Dimitriu and Stoia,[3] apparently seeking to improve upon the Whitehead method of removal and still to retain the advantages of that method, devised a technique of excision (somewhat resembling that previously described by Villard and Ricard[4] for rectal carcinoma), styled abdominoendoanal, in which the sigmoid is freed above, the gut excised below with preservation of the sphincter mechanism. Of 25 cases operated on by them, 19 are reported cured, 3 are dead, and 3 have recurred, which is an excellent record for such a complicated procedure. In 6 cases where their technique was found inapplicable, one-stage abdominoperineal excision was performed with 3 recoveries and 3 deaths.

Liccione[5] recently reported 2 cases of adenocarcinoma complicating the anorectal syndrome, 1 treated with radium, the other unsuccessfully operated upon by the abdominoperineal route, and invited the deduc-

tion that cases of inflammatory stricture which do not improve with local treatment or colostomy might be subjected to wide surgical removal.

Perineal excision has been generally frowned upon. Martin and Bacon[6] positively state: "Excision by either the perineal or sacral route carries with it a high mortality."

Naunton-Morgan[7] is equally emphatic in stating: "Perineal excision has been tried with fatal results."

The problem heretofore has been to find a method which will fulfill two requirements; namely, facility of execution and complete removal of the disease, with a reasonable chance of recovery.

The abdominoendoanal route, although admirable in the hands of its sponsors, would, for instance, hardly be applicable, because of operative risk, in some of the very sick whom we treat here. Besides, there is generally far too much low involvement to permit both preservation of the sphincters and total excision of the diseased area at the same time. This might also apply to the Whitehead technique, which incidentally must be very difficult if all of the involved bowel beyond the peritoneal reflection is to be removed. It would seem to be anatomically necessary, therefore, to adapt one or other of the radical operations used for cancer removal to the service of the anorectal syndrome, which, of course, narrows the choice to two main procedures and many modifications.

SELECTION OF CASES FOR EXCISION

This may be made on two possible grounds, local or general. Some effort has been made to correlate the clinical picture with the pathologic findings, particularly as regards those cases which display persistent general symptoms. It has been our observation that the purely stenosing lesions usually produce only local symptoms. But, when discharge is copious, tenderness marked, the infiltration relatively soft, the lumen narrowed but little, the mucosa of boggy consistency, with proliferative changes present in perianal integument and vulva, a gross picture of active inflammation, then may serious constitutional disturbance be expected. It is our belief that this type of picture, closely resembling that described as "hyperplastic" by Dimitriu and Stoia,[3] embraces nearly all cases that are clinically progressive, showing continued loss of weight, fever, and advancing secondary anemia. The difference between these two types is mainly a clinical one, but it is substantiated largely by the gross examination of operative specimens. The histologic differences between one and the other are probably only relative. Ulceration, cellular infiltration and fibrosis, replacement of the normal architecture, fatty and sclerosing changes in the perirectal tissues are present to a varying degree in both with obviously more fibrosis in the frankly stenos-

ing type. There can be little doubt that there are gradations between one and the other and that continued progressive infiltration is the consequence of failure of defenses against the disease, or unusual virulence of the infecting virus. A time factor may also be present in that some features of early involvement resemble "hyperplastic" lesions, but against this is the fact that many of the latter are of several years standing, and it is unwise to assume that they will eventually become stationary even after colostomy.

Long-continued clinical observation proves beyond question that some cases assume one or the other character at an early stage, but again it is equally true that fairly localized strictures may unexpectedly have superimposed upon them further inflammatory involvement which may progress along the bowel to an indefinite height. One gets the impression that pre-existing barriers have broken down and the infection has again assumed the upper hand. Grossly, then, there is still a stricture present with much softer infiltration in the upper parts of the lesion.

What is apparent in dealing with a number of cases of anorectal syndrome is that the more radical measures have been delayed until the general symptoms are far advanced. This is true in those cases which on exploratory laparotomy, preparatory to colostomy, show changes in the bowel wall involving the entire sigmoid and sometimes additional lengths of other parts of the colon, on rare occasions involving the entire colon. Performance of colostomy in such circumstances is of course futile because the advancing disease will most certainly involve the stoma within a short period after its creation. To those who advocate radical interference, there are two obvious conclusions. One is that, with these progressive lessions, something more than colostomy is indicated; and the other that excision, if attempted, must be done when the lesion is limited to such quarters as will permit its complete removal, with due regard for the patient's general condition, which is in direct proportion to the extent of the lesion.

With this in mind, therefore, the course adopted at Baltimore City and University of Maryland hospitals is somewhat as follows.

On admission, each patient is subjected to a period of observation lasting from a few days to a week or more. A general survey is made with particular attention to blood count, temperature record, and weight changes. As far as possible, some effort is made to gauge type of lesions. A firm but dilatable stricture in a patient with no fever, no anemia, and little loss of weight usually calls for dilatation and perhaps proctotomy, and there is usually little hesitancy in arriving at that conclusion, instituting treatment, and discharging the patient to report at periodic intervals to the out-patient department.

Any patient displaying fever, anemia, and giving a history of weight loss is kept under observation for a varying period to determine the effect of bed rest and supportive measures. In not a few, the general symptoms improve, occasionally to quite marked extent. It has been our observation, however, that this improvement is only temporary and that resumption of any degree of physical activity is accompanied by a corresponding return of general symptoms. It would almost seem that those who display fever, etc., at any one time are subject to future attacks until something more than palliation is adopted. In such circumstances laparotomy is therefore advised almost routinely, the extent of involvement determined, and loop colostomy at a good distance from the disease performed. Fortunately, it is usually found that the lesion stops just within the pouch of Douglas and the sigmoid is selected for the artificial anus. A further period of observation follows, extending from a few weeks to several months. At any time during this period, any loss of ground gained by the hospitalization and colostomy will point to the necessity for excision.

The operation performed with some measure of success in this series is the Lockhart-Mummery procedure; none other has been tried by us. Of six operated upon, one is dead, five are markedly improved. Although none has been followed for a period of longer than nineteen months, the results to date have been so encouraging that we feel they are worth while reporting in detail.

CASE REPORTS

CASE 1.—C. W., female, colored, aged 28 years, No. 14223, Baltimore City Hospitals. Admitted on May 18, 1936, and discharged on Sept. 4, 1936. Her only complaint on this occasion was rectal discomfort which she attributed to a continuous anal discharge and swelling of the perianal skin and of the external genitals.

In March, 1935, the patient had been admitted to this hospital with a similar complaint of five to six years' duration, the symptoms growing progressively worse during this period. On that admission it was noted that there was a "foul, purulent discharge from the rectum" and "tender thickened areas in lining of rectum as far as one can feel," with "moderate hypertrophy of the vulva."

A loop colostomy was performed on March 13, 1935, and she was discharged on April 6, somewhat improved. During her entire stay there was a constant evening temperature elevation to 100° or more, even to the day of leaving the hospital, and a hemoglobin of 54 per cent indicated a considerable degree of secondary anemia.

Examination on her second admission showed a well-functioning loop colostomy, a quite marked enlargement of the vulva, thickening of the perianal skin, and several large inflammatory tags at and near the anal margin. The parts were bathed in a purulent discharge escaping from the anus. Digital examination disclosed a markedly relaxed sphincter, very definite thickening of the entire rectal mucosa, with occasional elevations feeling almost polypoid in character. There was no evidence of stricture whatsoever.

Blood count taken on July 8, 1936, showed red cells 2,380,000; hemoglobin, 34 per cent; white cells, 6,450; Wassermann, 4 plus; Frei test not performed. Weight

on July 28, 100 pounds. Blood transfusion was ordered. Seven donors were cross-matched but none was compatible.

During a preliminary rest period of ten weeks, there was no improvement at all. There was a constant evening elevation, sometimes to 101°, pulse rate occasionally jumping to 120.

In view of these evidences of activity, excision was decided on and performed by the Lockhart-Mummery method on July 28, 1936, under spinal anesthesia. Much involved perianal skin, anus, rectum, and recto-sigmoid were removed with no great difficulty. Highest postoperative elevation was 103.2°; pulse rate 140 on July 29, both falling to reasonable levels eight days later. For the week before discharge, the temperature remained normal, which was the first time in our experience with this patient during two admissions that it had been so.

Fig. 1.—Case 2. Genitoanorectal syndrome. Brawny vulval and perianal involvement with several coarse skin tags.

Seen on Dec. 7, 1936, she was quite well and leading a nearly normal existence. The perineal wound had contracted to a small draining opening at its dorsal end. Weight, 111 pounds. There was also marked recession of the vulval swelling previously noted.

CASE 2.—M. B., female, colored, aged 41 years, No. 10512, Baltimore City Hospitals. Admitted on Aug. 5, 1936, and discharged on Aug. 26, 1937. This patient had had two previous admissions to this hospital, from Nov. 14, 1935, to Dec. 18, 1935, and from April 22, 1936, to June 23, 1936, on each occasion being treated for pellagra, of which there were the classical manifestations. On her present admission she was complaining of pain and weakness in the legs, with inability to walk, and it was assumed because of diarrhea and some residual dermatitis that she was again suffering from pellagra. It was apparent on initial examination, however, that in addition there was an extensive genitoanorectal lesion, but the patient could throw no light onto its duration or severity of symptoms. Her low

mentality also was a hindrance in obtaining a satisfactory history, and she could not recall having received any form of rectal treatment.

On admission the patient was found to be a mentally deficient, emaciated, obviously sick, colored woman with still some manifestations of pellagra. Perineal inspection revealed many brawny excrescences of varying size around the anus, with moderate hypertrophy of the labia minora and lesser involvement of the labia majora. There was moderate induration and some scattered superficial ulceration of the skin of the entire perineal region and the parts were very moist from mucopurulent discharge escaping from the anus, which was patulous. (Fig. 1.) On digital examination the finger encountered some narrowing about two inches from the anus, but not sufficient to impede the progress of a No. 8 Wales bougie. The mucous membrane above was found to be very irregular, thrown into numerous elevations

Fig. 2.—Case 2. Completely healed perineal wound 12 months after Lockhart-Mummery excision. Quite perceptible recession of vulval swelling.

and shallow depressions, and the consistence of the tissues generally was moderately soft and yielding.

The lower extremities were tender to touch and there was some hyperactivity of reflexes. The skin of exposed parts, although rough and scaly, was not erythematous.

The blood count showed red blood cells, 2,350,000; hemoglobin, 50 per cent. Catheter specimen of urine contained an occasional white cell, no albumin, no sugar. Wassermann, negative; Frei, positive.

Her weight on a recent previous admission had ranged from 91 pounds to 99 pounds in contrast to her usual weight of 125 pounds. The temperature range during the first two weeks of hospitalization was from 98 to 104.4° with regular nightly rise, settling down later to an evening elevation of about 100° at the time of her first operation (Nov. 4, 1936). Further oscillation was seen after colostomy

but seldom anything higher than 100°, although there were occasional sharp peaks. However, there was a persistent slight rise every evening until the middle of December.

The blood picture improved during this period and a count taken on Dec. 7, 1936, showed the red cells to be 3,900,000; hemoglobin, 70 per cent.

Rectal discharge at this time was still persistent and there was little alteration in rectal findings.

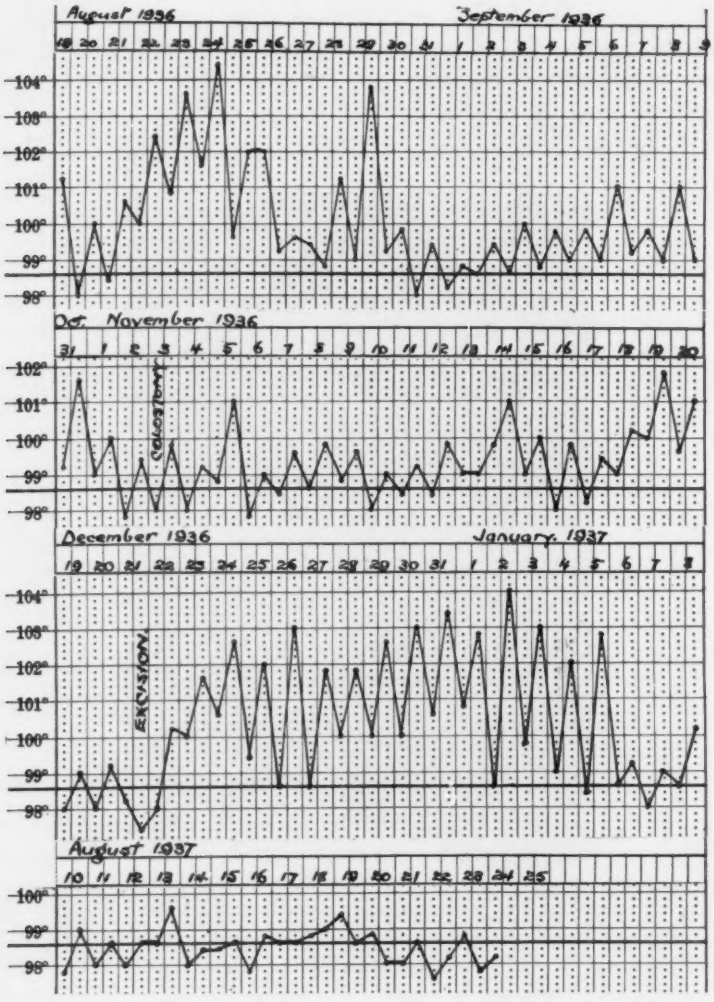

Fig. 3.—Case 2. Temperature record. *A*, Soon after admission; bed rest alone; *B*, following colostomy; *C*, following excision; *D*, just prior to discharge.

On Dec. 21, 1936, under general anesthesia, perineal excision of rectum and rectosigmoid, along with partial vulvectomy and removal of a portion of the posterior vaginal wall, was performed. Practically no difficulty was encountered either in the dissection of the entire lesion or in subsequent closure of the peritoneum. Blood transfusion, although apparently imperative in her case, was not given because of the lack of donors.

Postoperative course was of moderate severity. Evening temperature elevation to 103° was the rule from the fourth to the fifteenth day, but the pulse remained within a general radius of 100 to 105, never rising above 130 during this period.

From this time on there was gradual but uninterrupted improvement, both in the local wound and general condition. She became mentally clear, was able to walk within two months, and eventually made herself useful in attending minor needs of other patients around the ward.

A blood count, taken Jan. 16, 1937, showed 3,200,000 red cells; 58 per cent hemoglobin. Taken within such a short period of operation, this cannot be considered a serious setback. Weight on Aug. 17, 1937, was 120 pounds. The wound at the time of discharge was almost completely healed except for a minute granular opening just posterior to the fourchette. What was most interesting was that there was an almost complete recession of the vulval swelling. (Fig. 2.)

Fig. 4.—Case 2. Operative specimen. A progressive lesion, relatively soft, with moderate stenosis. A clear line of demarcation between diseased and apparently uninvolved mucosa can be seen at its upper end. Irregular ulcers alternate with "polypoid" elevations between this and the point of greatest narrowing. There is much coarse tag formation in the perianal skin. General symptoms marked. Operative removal relatively easy.

For several months we were unable to find any of her relatives, which accounts for her prolonged stay in the institution.

Follow-Up.—Dec. 13, 1937, perineal wound completely healed. Colostomy working well. No induration. Blood count showed hemoglobin, 64.8 per cent; red cells, 3,890,000. Weight, 116½ pounds.

CASE 3.—R. G., female, colored, aged 27 years, No. 6490, University of Maryland Hospital. Admitted on February 15, 1937, and discharged on May 9, 1937. Her chief complaint was constipation from which she had suffered for eight years,

following an operation for fistula in ano. In 1933 she was operated on for a rectal abscess and was first seen in the out-patient department of this hospital in May, 1936, still having great difficulty with the bowels. A tubular stricture was found at this time and the patient was treated with dilatation. The stricture was of unyielding character and she was sent to Baltimore City Hospital for dilatation under anesthesia. In spite of all subsequent efforts to keep the lumen of the bowel at a reasonable caliber, the stricture continued to contract, and patient had very infrequent stools and much pain on defecation. There was a quite persistent discharge from the anus, often containing blood in varying amounts. The consequent weakness and disability had kept her from following any continuous employment and she was advised to be admitted for colostomy. Weight, 130 pounds on Sept. 18, 1936.

On admission patient was found to be in quite good physical condition, in no immediate distress, and showing no indication of intestinal obstruction. Inspection

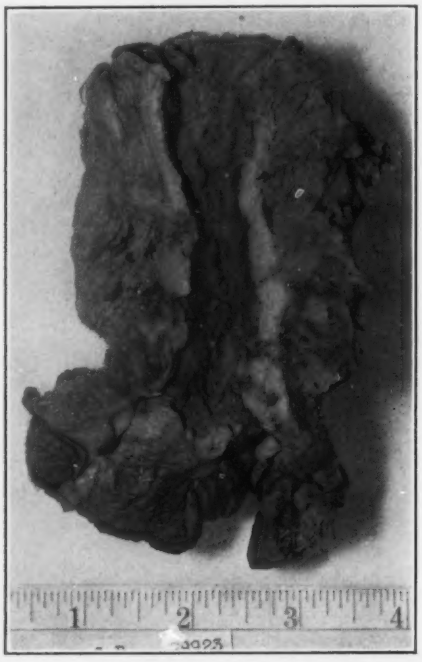

Fig. 5.—Case 3. Operative specimen. Tubular stricture with dense perirectal infiltration and many small fistulous tracts. General symptoms of mild degree. Operative removal difficult.

revealed much scarring of the perineal skin apparently from operations previously performed, but no brawny swelling and no tag formation. On digital examination the anus was found relaxed and a firm stricture was encountered within a short distance from the anus. Its caliber just about admitted the index finger, but much resistance was encountered as the finger was advanced and it was impossible to reach beyond the involved area. It was obvious also that there was much fixation of the rectum anteriorly but no evidence of any lesion of the vaginal mucosa.

Prior to operation there was a slight nightly elevation of temperature reaching on one occasion to 99.7° F. The blood count showed a mild secondary anemia, the red blood cells being 3,820,000; hemoglobin, 74 per cent; and white blood cells, 6,150. Blood Wassermann was negative; Frei test, positive. Other laboratory findings were essentially negative. The diagnosis was undilatable tubular stricture, the result of lymphogranuloma venereum, and colostomy was advised. A laparot-

omy was performed on Feb. 19, 1937, through a left paramedian incision under spinal anesthesia. There was found to be no involvement of the sigmoid colon, but the upper end of the rectal infiltration could be felt just below the peritoneal reflection from rectum to posterior fornix of vagina. A loop colostomy was performed through a left McBurney incision and the laparotomy incision closed. On Feb. 21, the colostomy loop was punctured for the relief of gaseous distention, and was completely severed on March 1. The temperature rose to 101.7° on the evening following operation, gradually subsiding almost to normal within two weeks, but always exhibiting a slight evening rise.

The question arose as to whether rectal excision was indicated in this case. The symptoms were mainly local and the lesion obviously stenosing, which would indicate that colostomy was sufficient in her case. However, there was some secondary anemia and slight evening elevation of temperature, and in addition a history of fairly constant bleeding, which had continued after colostomy. On these latter grounds, excision was advised.

The Lockhart-Mummery operation was performed on March 9. Great difficulty was encountered in releasing the rectum anteriorly, as lines of cleavage were practically obliterated. However, the entire lesion was eventually freed and amputation done well above the involved zone. The postoperative course was distinctly stormy in spite of two blood transfusions given respectively on March 10 and March 20. The daily temperature average during the first twelve days was from 102 to 103°, oscillating considerably during the next two weeks but gradually falling to normal levels by the first week in April and continuing so to the day of discharge. The pulse rate was correspondingly elevated during this period. The wound had become heavily infected but eventually granulated well and was contracting nicely when she left the hospital. Weight on discharge was 120 pounds.

Subsequent Course.—This patient has made several out-patient visits. The colostomy has been working well and healing of the perineal wound is proceeding apace. Her weight on July 12 was 144, a gain of twenty-four pounds since discharge and about fourteen pounds over her usual preoperative weight. Her blood count taken on Sept. 20 showed red blood cells, 4,070,000; hemoglobin, 66.2 per cent; white blood cells, 8,800. On Sept. 20, 1937, drainage was only in small amounts from a small sinus adjacent to the sacrum.

CASE 4.—L. L., female, colored, aged 29 years, No. 24855, Baltimore City Hospitals. Admitted on April 21, 1937, and discharged on June 25, 1937. Her chief complaint was rectal soreness. Her illness began three and one-half years previously with painful swelling to the right side of the anus, developing into an abscess which later ruptured. There were two recurrences of the same trouble, one month and one year later, during which period there was increasing difficulty with the bowels. During the four months prior to admission, she had several hemorrhages in varying amounts along with much purulent discharge. Rectal dilatation had played no part in the treatment of her condition. Her weight, usually around 116 pounds, had fallen to 108 pounds in August, 1936.

Rectal examination revealed some scarring of the perianal skin with no fistula, no protrusion, and no unusual swellings. Insertion of the finger was accompanied by considerable pain and some moderate degree of narrowing could be felt about 1½ inches from the anus of a caliber to admit two fingers. There was palpable thickening of the mucous membrane, which was thrown into folds and soft elevations, and there was a notable absence of scar tissue formation and fixation. Abdominal examination was negative.

Temperature on the evening of admission was 100° F., which about represents the daily evening elevation prior to colostomy. The red cell count was 3,500,000;

hemoglobin, 50 per cent; white blood cells, 6,000; urinalysis essentially negative; Wassermann, four plus; Frei test not performed.

The diagnosis was anorectal syndrome, probably of clinically progressive type, and colostomy with probable excision was advised.

Exploratory laparotomy was performed on April 27. The rectal lesion was found to extend to a level slightly above the peritoneal reflection, its upper limit being sharply defined. It was of soft consistence and there was no swelling of the mesentery and no lymph gland involvement. A loop colostomy was performed through a left gridiron incision. The colostomy was punctured for relief of gaseous distention three days later and completely severed on May 12.

There was an evening rise in temperature between 100 and 101° for eleven days, and a range from 99 to 100° daily until May 28, further evidence of intractability. On that date the rectum was removed to a point well above the extent of the lesion by the Lockhart-Mummery method. The day following operation the temperature rose to 103.8°, gradually falling to normal by June 19 and remaining unelevated from then on. The perineal wound drained freely at first but gradually contracted until, on Oct. 26, 1937, there was a small sinus adjacent to the vagina of a size scarcely to admit the lead of a pencil, with not sufficient discharge to necessitate the wearing of a pad. Two cubic centimeters of Carnoy's solution was injected on that date and there has been further contraction of the opening. The patient's weight on Nov. 8 was 117½ pounds. Blood count taken Nov. 20 showed 3,840,000 red blood cells; 58.6 per cent hemoglobin; and 6,050 white blood cells. At this time, except for some mild backache, she had no complaints and was largely occupied with her housework.

Follow-Up.—Jan. 10, 1938, weight 119¾ pounds. Perineal wound still draining slightly from small opening near the vagina. May 23, 1938, posterior wound completely healed; weight, 132½ pounds.

CASE 5.—J. B., female, colored, aged 38 years, No. 22920, Baltimore City Hospitals. Admitted on April 4, 1937, and discharged on Aug. 16, 1937. This patient was complaining of rectal pain, rectal discharge, and anal swelling, the duration of which could not be determined because of her almost complete deafness.

On examination, she was found to be in good general physical condition. Perineal inspection disclosed moderate perianal thickening and tag formation with an excess of moisture due to anal drainage. The finger inserted into the anus encountered a stricture of moderate density, with considerable swelling of the mucosa beyond, and no fixation. Moderate secondary anemia was indicated by a hemoglobin of 70 per cent. The temperature during the first six days oscillated between 97 and 100.2°. Frei test, positive; Wassermann, negative.

A loop colostomy was performed under spinal anesthesia on April 27, 1937, perforated two days later, and completely divided on May 12. On May 28, perineal excision by the Lockhart-Mummery technique was performed under spinal anesthesia. Maximum temperature was 101.8° on the fourth postoperative day; highest pulse rate was 120. There was a secondary elevation during the third or fourth postoperative week, attributable to a moderate pyuria. Subsequent course, however, was uneventful. Wound healing progressed normally and temperature and pulse rate remained entirely normal for the four weeks prior to discharge. Seen on Sept. 2 and 18, the wound was contracting well and the patient was resuming her normal activities.

CASE 6.—I. B., female, colored, aged 30 years, No. 24703, Baltimore City Hospitals. Admitted July 2, 1937, and died Sept. 10, 1937. This patient was a decidedly uncommunicative individual and could throw little light on the duration

of her illness. She complained of marked constipation and passage of blood per rectum for two weeks before admission, but it was natural to suppose that the onset of symptoms was at a much earlier date.

On examination, she was found to be a quite sick, emaciated woman. Perineal inspection revealed marked swelling and brawny infiltration of the vulva, with some superficial excoriation extending back over the perianal skin. There were some coarse inflammatory tags at the anal margin. The external sphincter was relaxed, and one inch from the anus there was a tight stricture. Withdrawal of the finger was followed by much pus and blood. Save for oral sepsis, the remainder of the physical examination was essentially negative.

Laboratory findings were as follows: urinalysis, 3 plus albumin on admission, but none eight days later. Blood count, red cells 3,900,000; white cells, 12,000; hemoglobin, 60 per cent; Wassermann, negative; Frei test was negative with what was proved to be an unsatisfactory antigen.

There was continuous temperature elevation from 99 to 102° with moderate pulse acceleration for the first twelve days. Exploratory laparotomy was performed on July 13, 1937. Soft infiltration of the gut was found to extend two inches

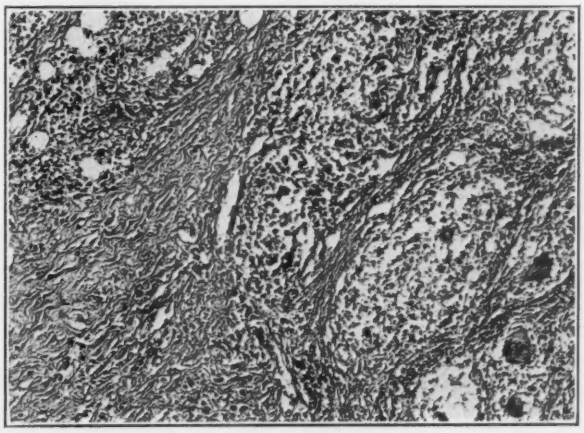

Fig. 6.—Case 5. Lesion in intestinal wall showing scar, cellular infiltrations, and tubercle-like lesions (×100).

above the peritoneal floor of the pelvis. A loop colostomy was performed through a left McBurney incision with purse-string closure of the left colic gutter. Postoperative course was far from encouraging. Temperature remained elevated, assuming "picket-fence" character during August. There was further concurrent emaciation and progressive anemia. Weight on Sept. 7 was 84 pounds; blood count on Sept. 5 showed 2,500,000 red cells; hemoglobin, 45 per cent. During this time also patient developed a marked toxic psychosis manifested by hallucinations, screaming, mutism, negativism, etc. There was no evidence of abscess formation or other detectable cause of fever, and none was subsequently discovered.

It was obvious that the patient was losing ground rapidly and that her only chance lay in operative removal of the rectal lesion with, if possible, blood transfusion. Donors, however, were not available.

A Lockhart-Mummery excision was performed on Sept. 8 under avertin basal and ether anesthesia. Separation of the lesion was easily accomplished, but there was difficulty with the sigmoidal stump and peritoneal closure. The patient's condition did not permit of extension of the operation through an abdominal incision.

Following this procedure, she became progressively worse and died on Sept. 10. Autopsy revealed necrosis of the sigmoidal stump with generalized peritonitis.

LESIONS

Macroscopically, all the lesions removed have shown some common features. The mucosa is eroded to a level almost corresponding to the reflection of the peritoneum from the posterior fornix of the vagina to the anterior aspect of the rectum with slight variation up or down, with ulcerated areas 6 to 15 cm. in length. A light of demarcation, somewhat scalloped in outline, encircling the entire bowel, exists between diseased and apparently uninvolved mucosa. The internal surface of the bowel below this level is the site of some degree of ulceration extending downwards to the anus, finally giving way to anal epithelium. The wall of the bowel and the perirectal tissues show thickening of variable depth and density.

In Case 3 the lumen of the bowel is narrowed and tubular from the anus to the upper limit of the lesion, which is firm, sclerotic, and almost cartilaginous in consistence. There are several fistulous tracts extending from the rectum in the lower part of the specimen. The erosion of the mucosa appears to be uniformly superficial. (Fig. 5.)

In Cases 2, 4, 5, and 6 the narrowing is not marked and is limited to the region of the ampulla, where the infiltration is relatively firm, increasing in suppleness upwards. The mucous membrane above the narrowing in this group of specimens shows ulcerations of irregular patterns; fairly deep ruts and grooves, alternating with ridges and rounded elevations to produce a somewhat polypoid appearance, due to the formation of vascular granulation tissue. (Fig. 4.)

The specimen in Case 1 differs from all of the others in that it shows no stricture formation. The mucosa is of distinctly polypoid character, and the mural and perirectal involvement is of relatively pliable consistence throughout.

In general, the degree of stenosis seems to be in direct proportion to the amount of fibrosis present.

Microscopically, the lesions are similar, varying only in degree and predominance of certain features of the picture. The ulcerated areas are lined by a vascular granulation tissue infiltrated by a variety of cells. The heaping up of this granulation tissue forms the mounds or polypoid masses of the gross picture. The raw surfaces have layers of purulent exudate or mucus clinging to them. The submucosa is thickened and fibrous. The inflammatory infiltrations involve all layers of the muscle and extend into the surrounding fat, and subserosal tissues. Fibrous tissue separates or replaces the muscle bundles and the surrounding tissues. (Fig. 7.)

In all cases the accumulations of lymphoid and plasma cells are massive (Fig. 8). Particularly in the muscular and serosal infiltrations they tend to be perivascular.

Eosinophile leucocytes are scattered through the lesions, varying in number, in two cases, 4 and 6, becoming very numerous. There are many mononuclear wandering cells.

There are numerous small abscesses or sinus tracts with a purulent exudate in the lumen. Often these contain bits of fecal material and foreign bodies. Sometimes they are lined by granulation tissue or show

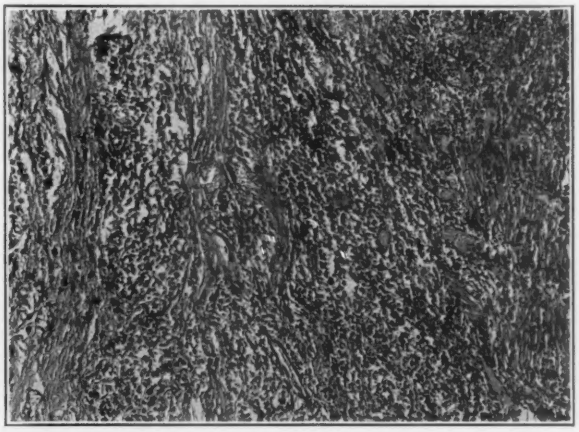

Fig. 7.—Case 1. Separation of muscle bundles by the accumulation of lymphocytes and plasma cells (×100).

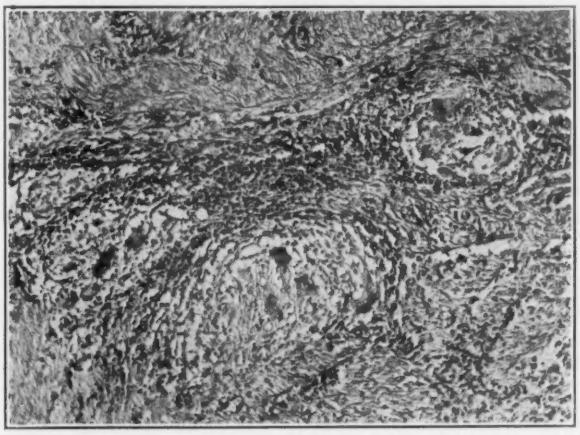

Fig. 8.—Case 4. Tubercles with epithelioid and giant cells, in an area of scarring and diffuse infiltration (×100).

an epithelioid cell boundary. Definite foreign body giant cells occur in these areas and, as in Case 5, there is calcification about such foreign bodies and in giant cells.

All the specimens, with the exception of Case 6, show in section a more definite type of focal lesion. Small nodules are found composed of epithelioid cells. In many areas these tubercle-like structures are made up of loosely arranged cells, some containing none, others one or two giant cells of the Langhans type (Fig. 8). In three of the cases,

1, 4, and 5, there are larger and more coherent epithelioid cell masses of larger size, in which only rarely a giant cell appears. In the central area of the mass there may be early necrosis with fragmentation of the larger cells and the appearance in such areas of polymorphonuclear leucocytes, and occasionally a central small abscess (Fig. 9). Such lesions are present in Cases 4 and 5. No caseous areas are present and no acid-fast organisms could be found.

In only two of the cases, 5 and 6, were sections made to show the proximal end of the specimen which in the gross appeared normal. In one the intact mucosa and submucosa are only slightly infiltrated with lymphocytes, a few plasma cells and eosinophile leucocytes, while the other layers are normal. In the other instance, Case 5, the mucosa is normal, but the submucosa, muscularis, and serosa contain slight perivascular infiltrations.

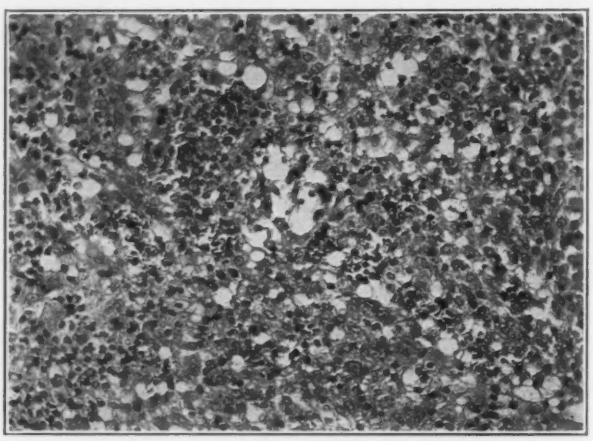

Fig. 9.—Case 4. Early necrosis and polymorphonuclear neutrophile leucocytes in the center of a mass of epithelioid cells (×200).

COMMENT

Some question may arise as to the necessity for the course adopted in these cases. Marked constitutional disturbance associated with a nonstenosing, highly infiltrative type of lesion, may have advanced to such a degree that no type or amount of therapy will serve its purpose. It is therefore of paramount importance that progressive lesions be recognized while the patient's condition will still permit operative removal. Once the lesion has advanced beyond the sigmoid flexure, the operation of complete extirpation becomes a very formidable procedure which proportionately severe absorptive phenomena will not permit. It should be our aim, therefore, to attempt recognition of progressive lesions while they are still limited to the rectum and rectosigmoid. This, one is inclined to believe possible, if, in the usual running of outpatient departments, occasional attention is given to the general condition of these patients. Observance of weight changes, occasional blood

count, the taking of temperatures, the patient's own account of her physical activities, may shed some light on chronic illness and disability not at first suspected.

As to the choice of operation, perineal excision has been used in this short series because of its apparent adequacy for the cases selected. It has the advantage of relative ease of execution and much less postoperative disturbance than in any combined abdominoperineal procedure. In addition, we are not concerned with metastatic involvement as in the treatment of carcinoma. Should occasion arise, and provided reasonable care has been taken in avoiding contamination of the perineal wound, it might be possible to continue the excision through an abdominal incision.

It is to be admitted that this series and the elapsed time are too short to draw any positive claims as to cure. In all five surviving patients, however, there has been a cessation of fever, decided gain in weight, some improvement in the blood picture, and the patients have been able to resume some part of their previous occupations. In only two, so far, however, has there been complete healing. In another the fistulous opening was practically closed when last seen, and in the remaining two healing was proceeding satisfactorily.

It may be asked whether there exists after these excisions any further evidence of "cure," especially from concurrent improvement of vulval or other lesions. It can be definitely stated that in two of these cases there was visible diminution in vulval swelling (Figs. 1 and 2). Beyond that we would not yet wish to speculate.

That there may be more inflammation higher than the level of macroscopic involvement has been shown by histologic study, but in no case so far has there appeared any clinical evidence of disease in the distal stoma of the loop colostomy.

SUMMARY

1. Six cases of anorectal syndrome of lymphogranuloma inguinale are presented.

2. In one of the cases the lesion consisted of a dense tubular stricture with no other involvement.

3. In the remaining five, the principal feature was a softer involvement extending up to and slightly beyond the peritoneal reflection.

4. Of these five, there was a firm diaphragmatic stricture in one, some slight narrowing in three, and no narrowing whatsoever in one.

5. In all there was a varying amount of weight loss, secondary anemia, continued fever.

6. All were subjected to preliminary laparotomy and loop colostomy, followed later by perineal excision of the Lockhart-Mummery type.

7. Five have survived and have shown decided general improvement.

CONCLUSIONS

1. In the absence of any specific therapy for lymphogranuloma inguinale, it should be recognized that surgical measures still play the leading part in treatment of anorectal lesions.

2. In those cases which fail to respond to ordinary palliation, excision should be given early consideration.

3. Lockhart-Mummery method of excision appears to be applicable to certain cases and is not necessarily attended by a high immediate mortality rate.

4. Results in this short series so far have been gratifying but are by no means conclusive.

The photomicrographs are by Mr. Milton Kougl.

REFERENCES

1. Hartmann, H.: Lancet, 307, 1922.
2. Yeomans, F. C.: Tr. Am. Proct. Soc., 70, 1933.
3. Dimitriu, V., and Stoia, I.: Les rectites infiltratives, Paris, 1933, Masson et Cie.
4. Villard, E., and Ricard, A.: Lyon chir. **22**: 129-160, 1925.
5. Liccione, W. T.: Am. J. Surg. **31**: 551, 1936.
6. Martin, C. F., and Bacon, H. E.: Internat. Clin. **4**: 250-279, 1935.
7. Naunton-Morgan, C.: Practitioner **139**: 423, 1937.

PERORAL INTUBATION AND DRAINAGE OF THE SMALL INTESTINE

Technique and Indications

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In 1934 Miller and Abbott[1] described a practical technique for intestinal intubation by which a tube would pass rapidly into the jejunum and often into the ileum. The apparatus provided an adequate lumen for the extraction of intestinal contents, and also permitted kymographic recording of pressure changes within the intestinal tract and the injection of substances directly into the stomach, duodenum, or the small bowel. Furthermore, its introduction was little more disturbing to the patient than the passage of an ordinary duodenal tube, and it could be easily and quickly withdrawn.

After considerable experimentation, they devised a rubber tube with two lumina, one of which was used for extraction and injection, and the other for inflation and deflation of a collapsible rubber bag attached to its distal end. This bag, when distended, simulated a bolus of food and was carried along the intestinal tract by intestinal peristalsis.

The technique of intubation was as follows: The tube with the bag deflated was passed into the stomach. The patient was then turned on his right side and more of the tube was introduced slowly until its distal end had reached the duodenum. Entrance into the duodenum was determined by the character of the contents obtained through the tube or, preferably, by fluoroscopic observation. When the tube had reached at least the third portion of the duodenum, the rubber bag was distended moderately with air or fluid. The tube was then gradually swallowed at the rate of about 5 cm. every ten minutes.

In their conclusions, it was suggested that the apparatus "may lead eventually to new methods of diagnosing and treating intestinal lesions."

This method of rapidly intubating the small intestine has since been applied clinically by Abbott and Johnston[2] to the problem of the localization, diagnosis, and treatment of obstructive lesions of the intestinal tract.

*Their apparatus consisted of two tubes, one a No. 14 or No. 16 F. duodenal tube tied to a No. 3 F. tube bearing a thin rubber inflatable balloon at its tip. In normal individuals it was found that the apparatus

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*Recently a soft pliable double-lumen tube has been devised which has proved satisfactory. It is manufactured by the G. P. Pilling & Son Company, Philadelphia, Pa.

advanced through the intestine at the rate of about 1 cm. of tube per minute (2 feet per hour), and about half as rapidly in obstructed cases. A length of only 6 or 8 feet of tube was generally sufficient to reach from the pylorus to the cecum. They were able to decompress the abdomen by completely emptying the entire small intestine proximal to an obstruction and, in certain cases, to restore normal intestinal action without the necessity of surgical intervention. They showed that a distended and silent jejunum or ileum, or one vigorously manifesting reverse flow, resumed normal motor function when decompressed, thus producing rapid symptomatic relief in both mechanical and paralytic obstructions. In addition, they were able to identify both the position and nature of certain obscure obstructing lesions by x-ray examination after injecting a small amount of a barium sulfate suspension through the tube which had first been advanced to the point of obstruction.

Peroral intubation of the small intestine marks a great advance in the treatment of intestinal obstruction. Its use preliminary to operation provides an opportunity of improving the patient's condition by restor-

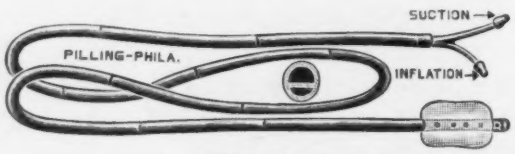

Fig. 1.—Miller-Abbott tube.

ing his depleted fluids and electrolytes. Moreover, the reduced distention and the relief of edema of the intestine at the site of obstruction renders the operative procedure safer and easier. In some cases, nonsurgical intestinal decompression will be sufficient to permit spontaneous relief of the obstruction.

However, as pointed out by the authors, there are certain conditions which call for immediate operation. These include cases in which compromise of the circulation of the bowel is suspected, or where there is an obvious cause for the obstruction, such as an external hernia.

At the Mount Sinai Hospital we have had the opportunity of employing the Miller-Abbott tube for the relief of intestinal obstruction, with gratifying results. We have further extended the indications for its use to include the preoperative preparation and postoperative management of patients requiring operations on the small or large bowel. In these cases, intestinal drainage has as its purpose the facilitation of the operative procedure, and the prevention of postoperative distention in order to relieve strain on suture lines and reduce the danger of peritoneal infection.

The only difficulty that we have encountered with the method has been to get the tip of the tube to enter the duodenum. In some cases,

simply passing the tube slowly with the patient on his right side has been successful in less than an hour. In others, however, despite fluoroscopic observation and manipulation, the tube has required up to two days to pass the pylorus. In five out of fourteen cases intubation could not be accomplished. We have not been able in any case actually to push the tube through the pylorus under fluoroscopic visualization. Observation under the fluoroscope has been of aid only in directing the tube towards the pylorus and in determining whether it was coiled in the stomach. From our experience we cannot agree with the statement of Abbott and Johnston that "the tip of any tube is usually found to have entered the duodenum before it has been many hours in the stomach," for in several of our unsuccessful cases, the tube remained in the stomach for as long as three days.

The following is the procedure employed in passing the tube: The nose of the patient is first examined to determine the presence of deviation of the septum or enlarged turbinates which might obstruct the passage of the tube. The more patent side of the nose is sprayed with cocaine and then with albolene for lubrication. Thus the passage of the tube through the nose is rendered painless. The tube is then passed into the stomach, and, with the patient lying far over on the right side, it is fed very slowly to reach the duodenum. In cases showing marked retrograde flow of intestinal contents the stomach often contains bile and intestinal fluid. If fluoroscopic examination is not feasible, it will be difficult to determine when the tube has passed the pylorus. We have found the following procedure to be useful. About one-half tumblerful of water tinted with methylene blue is given by mouth. If immediate suction brings back colored fluid we know the tube is still in the stomach; otherwise, it is presumed to have entered the duodenum. The balloon is then inflated with about 30 c.c. of air and the tube fed gradually at the rate of about 3 to 6 inches every fifteen to twenty minutes. Continuous suction drainage is maintained.

Nearly all the patients complain of soreness of the throat after the tube has been in place for a few hours. Frequent hot saline throat irrigations will be found helpful in relieving these symptoms and, in addition, the nose should be frequently sprayed with albolene to prevent crusting and erosions.

The following cases are reported in detail to illustrate several of the indications for which we are using intestinal intubation and decompression by the Miller-Abbott method, and to present certain technical features of the procedure.

CASE 1.—M. B., 420841. The patient was a man, 40 years of age, who was admitted to the hospital with a six months' history of attacks of upper abdominal distention associated with cramps. Six months ago he had diarrhea for several weeks, and he occasionally passed blood and pus. He became emaciated. Three weeks ago diarrhea recurred.

Despite the fact that he was able to pass flatus occasionally, the abdominal distention increased over several days. He vomited frequently and complained of cramps. X-ray examination with the barium enema revealed complete obstruction at the hepatic flexure of the colon.

In view of these findings, surgical decompression of the intestinal tract was considered indicated. Cecostomy was proposed as the first stage of resection of what was thought to be an obstructing carcinoma of the hepatic flexure. It was decided, however, to attempt decompression first with the Miller-Abbott double-lumen tube. The tube required about nineteen hours to pass into the duodenum. The balloon was then distended and the tube fed gradually. Profuse drainage of small intestinal contents began immediately.

The abdominal distention was markedly relieved during the next twenty-four hours and then the drainage became scanty. After several days, mouth feeding was begun and was well tolerated. On the fifth day colonic irrigation obtained excellent return of gas and feces. Barium enema x-ray examination was repeated and showed that some barium had passed by the obstructing lesion. After nine days of intestinal drainage, during which time the patient's general condition had greatly improved, operation was performed. The intestine was satisfactorily collapsed and the tip of the tube was felt in the lower ileum. The obstructing lesion proved to be a peritoneal band which spread from the anterior surface of the mesentery of the transverse colon across the hepatic flexure to become fixed to the undersurface of the liver. The band was divided and the obstruction relieved. The tube was permitted to drain for another day and was then withdrawn. There was no postoperative distention and but little discomfort. The patient made an uneventful recovery.

Comment.—In the face of intestinal obstruction, nonsurgical drainage of the intestine promptly and efficiently accomplished decompression. It was then possible to improve the patient's condition in preparation for operation by continuous intravenous glucose and saline, blood transfusion, and feeding by mouth. Secondly, the relief of intraintestinal tension and pressure of accumulated gas and fluid proximal to the obstruction apparently permitted the local edema about the obstructing lesion to subside and partially to re-establish the patency of the intestinal lumen. Operation, when finally undertaken as an elective rather than an emergency procedure, was attended with much less technical difficulty because of the collapsed condition of the intestine, and was less hazardous in view of the improved general condition of the patient. In addition, there was no intestinal distention postoperatively and but little discomfort.

CASE 2.*—S. B., 421091. The patient was a boy, 14 years of age, who was admitted to the Semi-Private Pavilion with a typical history and the physical signs of acute appendicitis. Operation was performed immediately. The appendix was kinked and gangrenous in its distal third; it was situated laterocecally, was densely adherent, and was removed with difficulty. On the eighth postoperative day the patient coughed suddenly and immediately felt pain in the region of the wound. On the following day a partial wound evisceration with protruding omentum was demonstrated. There was nausea and vomiting, and the temperature rose to 103° F. On the twelfth postoperative day the patient appeared to be very ill and presented the clinical picture of advanced peritonitis. He had not passed gas or feces for

*This case is reported through the courtesy of Dr. L. Ginzburg.

several days. Suction drainage by means of the Levin tube produced no improvement, although considerable quantities of intestinal fluid were evacuated. The Miller-Abbott tube was then passed. Because the patient was too sick to be transported to the x-ray department, and because of the fact that the stomach contained foul turbid brown fluid, it was difficult to decide when the tip of the tube had

Fig. 2.—Case 1. Decompression of the abdomen for intestinal obstruction due to a constricting band at the hepatic flexure of the colon. At operation, the tip of the tube was palpated in the lower ileum.

entered the duodenum. To determine its position, the following procedure was employed: The patient was given about a half tumblerful of water colored by methylene blue. The blue solution was immediately recovered by suction through the tube, indicating that its tip was presumably still in the stomach. The latter was then completely emptied and continuous suction drainage instituted. The foul

turbid brown fluid obtained varied in reaction from strongly acid to neutral to faintly alkaline as tested with litmus. On the following morning methylene blue water was again given but this time could not be recovered. The tip of the tube was now considered to be in the duodenum. The balloon was inflated with 30 c.c. of air and the tube fed at the rate of about 3 inches every fifteen minutes until its entire length had been passed. Continuous suction drainage obtained copious quantities of gas and small intestinal contents. The reaction of this material was faintly acid. After twelve hours there was some diminution in the abdominal distention and a definite improvement in the patient's condition.

An interesting phenomenon was then observed. Despite the fact that the tube was proved to be patent, drainage ceased. The balloon was deflated and several feet of the tube withdrawn. Drainage was immediately resumed. The balloon was then reinflated and the tube passed again. In order to maintain continuous drainage, it was necessary to repeat this maneuver once or twice each day.

The patient continued to improve slowly. The distention was relieved. There was no vomiting. After eight days the patient began to pass gas and fluid stools by rectum. Two days later a fecal fistula appeared in the wound, together with profuse purulent discharge. Following this, the temperature fell by lysis. Mouth feeding was then begun, and the intestinal tube clamped off for progressively longer periods without discomfort until the twelfth day, when it was removed. The abdomen was now soft and the patient apparently well on the way to recovery. The fecal fistula healed spontaneously and the patient left the hospital in good condition.

Comment.—We feel that, in this case, the continuous drainage of the small intestine was a lifesaving measure. Despite profuse drainage with the Levin tube, the patient continued to go downhill. Continuous small intestinal decompression, however, brought about progressive relief of the abdominal distention and apparently helped to tide the patient over the period of peritoneal infection.

This case also illustrates the well-known fact that it is often impossible to drain more than a limited segment of the intestine by one fixed point of drainage because of the accumulation of gas and fluid in the flaccid intestinal loops above the level of drainage. Thus, surgical drainage (enterostomy) is of very limited value in paralytic ileus. By repeatedly advancing and partially withdrawing the double-lumen tube, however, continuous drainage of a large area of the intestine may be readily accomplished.

CASE 3.*—H. W., 422302. The patient was a colored woman, 37 years of age, admitted to the Gynecological Service with a history of left lower quadrant pain of three weeks' duration. Pelvic examination revealed the presence of uterine fibroids and chronic inflammatory adnexal disease. Supravaginal hysterectomy and bilateral salpingo-oophorectomy were performed. Table I is an outline of the patient's clinical course.

Comment.—This case is cited as an example of postoperative intestinal obstruction due, possibly, to a kinking of a loop of intestine by an inflammatory adhesion. The relief of proximal intestinal tension probably permitted the obstruction to become relieved spontaneously.

*This case is reported through the courtesy of Dr. I. C. Rubin.

TABLE I

4/6/38	Operation
4/8/38	Vomited bile-stained fluid
4/9/38	Unable to retain fluids
4/10/38	Passed gas and feces with enema, vomited; Levin tube passed, Wangensteen suction begun
4/11/38	Had abdominal cramps; gastric lavage obtained brown fluid; Levin tube drainage discontinued
4/12/38	Vomited again; vomitus had foul odor; Levin tube passed again
4/13/38	General condition was fair; patient was listless and had abdominal pain; had not passed flatus; abdomen was markedly distended; Wangensteen suction drainage was working well; wound dressed, large quantity of foul-smelling pus containing air bubbles evacuated from upper angle of wound which was separated down to peritoneum
4:00 P.M.	Patient was very apathetic, had abdominal pain; Levin tube drained dark brown fecal-smelling fluid.
8:00 P.M.	Vomited 150 c.c. of fecal-smelling fluid despite continuous Levin tube drainage
10:45 P.M.	Enema given; return clear; no flatus
4/14/38 4:00 A.M.	Patient was very apathetic; the skin was cold and clammy; abdomen was distended; general condition was fair; Levin tube draining fairly well
10:00 A.M.	Complained of abdominal pain
12:30 P.M.	Miller-Abbott double-lumen tube passed; stomach drained of turbid brown fecal-smelling fluid
1:30 P.M.	Water colored with methylene blue was given by mouth but could not be aspirated through the tube; consequently, it was felt that tip of tube had passed beyond pyloric sphincter; balloon was inflated; immediately patient complained of a cramplike pain in upper abdomen and there was a gush of gas and intestinal fluid through tube; few minutes later there was another cramp soon followed by another gush of gas and intestinal fluid; this happened repeatedly; this phenomenon of pain followed by drainage through tube was interpreted as contraction of intestine upon inflated balloon, thus propelling tube forward and draining successive loops of small intestine
4:00 P.M.	Tube drained profusely; patient was quite comfortable; her skin became warm and her general condition improved; she had cramplike pains at times.
4/15/38	Patient's general condition was better; abdomen was not distended; drainage through the tube was moderate; patient took fluids by mouth
4/16/38	Tube drained well; patient took fruit juices and semisolid foods by mouth; abdomen was soft; feces and much flatus passed with enema.
4/18/38	Tube was removed; patient was taking nourishment well and was passing gas by rectum.

The case also illustrates another use for intestinal decompression, aside from the relief of an obstructive or paralytic ileus; namely, the reduction of intra-abdominal pressure to prevent evisceration through a wound already markedly weakened by infection. In this patient the

wound was separated down to the peritoneum, and it was feared that the continued strain of abdominal distention might complete the dehiscence.

CASE 4.—R. W., 422630. The patient was a woman, 47 years of age, who came to the hospital with a history of constipation and intermittent colicky lower abdominal pain for one month. These symptoms had gradually progressed until three

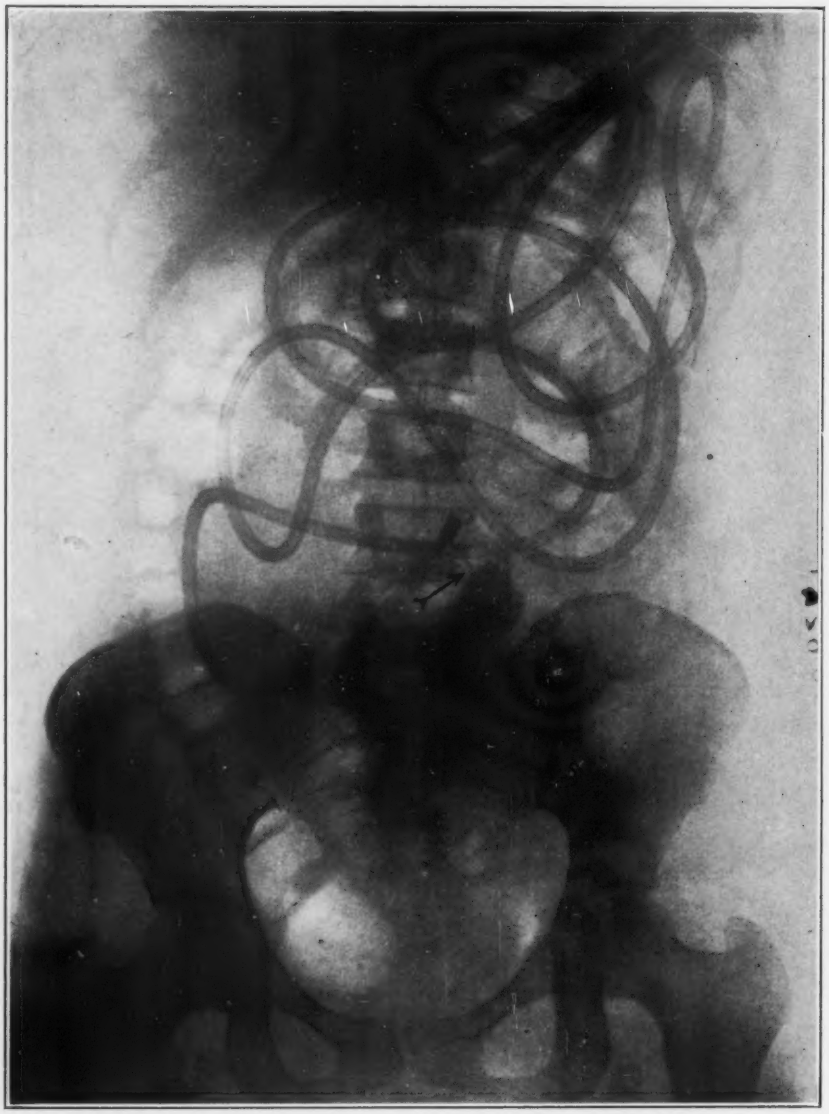

Fig. 3.—Case 3. Small intestinal drainage for postoperative ileus. In the roentgenogram the tip of the tube is seen in close proximity to the shadow of the gauze packing in the wound (indicated by the arrow). The arrest of the tube at this level suggests the possibility of obstruction on the basis of an inflammatory adhesion of the small bowel in the region of the infected wound.

days before admission, when they became severe. There were no further bowel movements. On admission the patient appeared ill. The abdomen was distended and there was audible peristalsis. X-ray examination of the abdomen revealed dilatation of the small and large bowel.

The clinical course is shown in Table II.

Comment.—Although the obstructive manifestations had been partially relieved before intubation of the small intestine had been accomplished, drainage was continued to provide for decompression during the period of temporary obstruction produced by the operative procedure.

Fig. 4.—Case 4. Drainage of the small intestine preliminary to "obstructive resection" of a carcinoma of the splenic flexure of the colon. At operation, the tip of the tube was felt in the lower ileum. Decompression was continued postoperatively.

CASE 5.—W. P., 423039. The patient was a man, 31 years of age, with a five-year history of attacks of lower abdominal cramps associated with diarrhea and vomiting. These episodes occurred every one to three weeks, and each lasted about two to six hours. He had lost twenty pounds.

TABLE II

4/12/38	8:00 P.M. Enema was given; no flatus obtained
4/13/38	9:30 A.M. Enema was given; no feces obtained, but a small amount of flatus was expelled
	1:30 P.M. Miller-Abbott double-lumen tube was passed into stomach
4/14/38	10:00 A.M. Enema was given; flatus and feces passed; intestinal obstruction was apparently partially relieved
	4:00 P.M. Tip of tube was apparently in duodenum; balloon was inflated and tube fed gradually; suction drainage obtained moderate amount of gas and fecal-smelling fluid
4/15/38	4:00 A.M. Tube drained well; patient complained of severe abdominal pain; abdomen was soft
4/16/38-4/25/38	Drainage was scanty, although tube was proved to be patent
4/17/38	Barium enema x-ray examination revealed a lesion at the splenic flexure of the colon which, however, did not obstruct retrograde flow of barium; diagnosis was carcinoma of colon; on the following day material which drained through the tube contained what appeared to be some of the barium mixture used in the barium enema; by this time abdomen was flat, and patient was passing gas and feces normally by rectum.
4/25/38	Operation was then performed; tip of tube was found in lower ileum; intestines were well decompressed; an "obstructive resection" of a splenic flexure carcinoma was performed
4/27/38	Drainage was scanty; tube was removed; convalescence, aside from a pneumonic infection, was satisfactory.

On physical examination a mass was found in the right lower quadrant, and x-ray investigation revealed the presence of a constricting lesion involving the terminal ileum, cecum, and ascending colon.

Preoperatively the Miller-Abbott tube was passed, requiring almost two days for the tip to enter the duodenum despite manipulation under the fluoroscope and the fact that the patient was kept continuously on his right side. The intestine was drained for three days and then operation was performed. The tip of the tube was found situated at the ileocecal junction. The intestinal lesion consisted of an inflammatory process at the ileocecal angle. Ileosigmoidostomy with exclusion was performed. Continuous suction drainage was maintained postoperatively. The patient had an entirely uneventful course. There was no postoperative abdominal distention and very little discomfort. The tube was removed on the fourth postoperative day.

SUMMARY

1. The Miller-Abbott method of small intestinal intubation has been used with gratifying results in the treatment of intestinal obstruction.

2. Drainage of the intestine by this method is suggested in the preoperative preparation and postoperative management of patients requiring operations on the small or large bowel.

3. Certain technical aspects of the procedure are discussed.

4. Illustrative cases are presented.

REFERENCES

1. Miller, T. G., and Abbott, W. O.: Intestinal Intubation: A Practical Technique, Am. J. M. Sc. **187**: 595-600, 1934.
2. Abbott, W. O., and Johnston, C. G.: Intubation Studies of the Human Small Intestine, Surg., Gynec. & Obst. **66**: 691-697, 1938.

THE OPERATIVE INCIDENCE OF PANCREATIC REFLUX IN CHOLELITHIASIS

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THE observation by Opie[1] of a calculus impacted in the ampulla of Vater in a case of acute hemorrhagic pancreatitis was a historic landmark in the investigation of diseases of the biliary-pancreatic system. The proof that occlusion of the papilla of Vater could, under certain anatomic conditions, convert the biliary and pancreatic ducts into one intercommunicating system clearly demonstrated that acute pancreatitis might be produced by the retrojection of bile into the pancreatic duct. It also raised implications that the converse possibility might occur, that is, the passage of pancreatic juice into the biliary system under similar conditions. The experimental proof by Archibald[2] that spasm alone of the sphincter of Oddi could produce a reflux was of great importance since it tended to explain the anomolous finding that about half the cases of acute pancreatitis occurred in patients with a normal biliary tract.

Since the anatomic condition which renders biliary-pancreatic reflux possible requires that the pancreatic duct should open into the common bile duct proximal to the sphincter of Oddi, considerable research has been done as to the incidence of such a condition in the human being. The findings of various investigators using autopsy material are summarized in Table I. Opie was apparently the first to point out that if the pancreatic duct enters the common bile duct near the tip of the papilla, an impacted stone in the ampulla would occlude both ducts and so prevent reflux in either direction. He stated that although 89 out of 100 cases investigated had a common channel, in his opinion the impaction of the stone at the papilla might lead to a possible reflux in only 21 per cent of the cases. Judd as well as Mann and Giordanno stated that although the pancreatic duct opened into the common bile duct in a large percentage of cases, only about 4 per cent of the cases investigated possessed an ampulla of sufficient length to permit reflux to occur.

Schmieden and Sebening, after occluding the tip of the papilla, injected lipiodol into the common bile duct. Roentgenograms showed that the iodized oil simultaneously outlined the pancreatic duct in 20 per cent of their cases. Subsequently Cameron and Noble, after occluding the papilla with a small stone, poured Wood's metal into the choledochus and noted that the duct of Wirsung was present in the mold in 74 per cent of the cases.

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TABLE I

ANATOMIC INCIDENCE OF A COMMON AMPULLA IN THE HUMAN BEING

AUTHOR	NO. CASES	COMMON AMPULLA (%)	AMPULLA LARGE ENOUGH TO FORM COMMON PASSAGE AFTER STONE IMPACTION (%)
1. Letulle, Nathan-Larrier[3]	21	38	
2. Ruge[4]	43	75	
3. Opie[5]	100	89	21.0
4. Baldwin[6]	90	78	
5. Osler[7]	100		32.0
6. Schmieden, Sebening[8]	35		32.0
7. Judd[9]	170		4.5
8. Mann and Giordanno[10]	200	69	3.5
9. Cameron and Noble[11]	100	74	66.0

These investigations were all performed on cadaver material. The percentage of cases in which the ampulla was considered large enough for the formation of a common passage after calculus obstruction was dependent on the opinion of the observer. It would appear that a better approach to the problem would be obtained if the incidence of pancreatic reflux could be ascertained during drainage of the common bile duct. It is now generally accepted that if the choledochus and the duct of Wirsung empty in a common ampulla proximal to the sphincter, any factor causing an occlusion of the papilla of Vater may convert both ducts into a common canal. This obstruction may be caused either by impacted papillary calculus or edema about the orifice, or a sphincteric spasm. Once this common canal has been established, it is possible that either the bile may enter the duct system of the pancreas or pancreatic juice may flow into the extrahepatic bile ducts. The factor which determines the direction of the reflux is probably the relative secretory pressure of the biliary and pancreatic fluids. While there is much controversy in regard to these pressures, most authorities agree that the pressure is higher in the pancreatic duct. However, if the accessory duct of Santorini is present and communicates with the duct of Wirsung, the resultant pressure in the main pancreatic duct probably will be lowered. Drainage of the common bile duct such as occurs in a choledochostomy may sufficiently lower the intracholedochal pressure so that pancreatic juice will flow into the common bile duct under these conditions. The pressure factors during biliary drainage are however very much like the normal, since bile flows through the drainage tube against a resistance of 90 to 110 mm. of water (the height of the abdominal wall above the choledochus). It is therefore not too far fetched to postulate that if the resistance of the sphincter of Oddi has remained unchanged, pancreatic reflux has probably also occurred in these patients prior to operation.

In the past, the retrojection of the pancreatic secretion in the bile was only suspected in those cases in which the skin about a biliary fistula became macerated and digested. Nordmann[12] records two cases of acute

pancreatitis in which pancreatic ferments were present in the drainage from a choledochostomy, and Westphal[13] also demonstrated large quantities of ferments in a dilated choledochus. In a previously reported series[14] of fifty-four cases of common duct stone in which a choledochostomy was performed, evidence of pancreatic ferments was found in but two instances. The bile was examined for trypsin in these few cases, only because a marked dermal irritation and digestion about the biliary fistula suggested its possible presence. Pancreatic ferments in the bile are evidently not as rare as the paucity of these case reports would indicate. Popper[15] recently reported the results obtained in 219 surgical patients in which the bile (usually from the gall bladder) was specifically examined to determine the presence of pancreatic ferments. He was able to demonstrate increased amounts of amylase in 17 per cent of the cases by the Wohlgemuth method. The cases in which the bile ducts contained pancreatic juice differed in no way from other cases of cholelithiasis in regard to history, symptomatology, clinical course, operative findings, postoperative course, and follow-up results. Evidently pancreatic reflux is not a rare occurrence.

While we were unable to find amylase by the Elman viscosimeter method,[16] in a routine examination of the bile obtained from the gall bladder in a series of twenty-seven cases of chronic cholecystitis, large amounts of amylase were found in four out of fourteen cases of acute cholecystitis, in which the cystic duct was not occluded. Three of these cases of acute inflammation of the gall bladder, due to pancreatic ferments, have been previously reported.[17] In a routine analysis for amylase in the bile obtained from the choledochostomy drainage in thirty-five patients operated upon for either cholelithiasis or choledocholithiasis the ferments were present in ten patients. The chemical demonstration of pancreatic ferments in the bile in sufficient concentration invariably points to an intermittent obstruction at the papilla of Vater and the conversion of the bile and pancreatic ducts into a common canal. The presence of these enzymes can only be accounted for by a pancreatic reflux, in the absence of a duodenal fistula.

No organic obstruction was found in any of the cases observed by us, as proved by x-ray visualization of the biliary tract and by pressure readings. In all patients with choledochostomy drainage, when amylase was found at all, it could be noted daily throughout the course of drainage. The concentration of amylase was always highest during periods of activity of the pancreas, i.e., following the noon and evening meals, and often disappeared during the late night and morning. These findings support the experimental evidence adduced by Archibald that spasm of the sphincter of Oddi is sufficient to cause reflux.

Popper, as a result of his investigations of pancreatic reflux, predicated that if pancreatic ferments were found in the bile in significant concentrations, a direct anatomic communication must exist between the

bile and pancreatic ducts. If the premise of Popper is correct, then in those cases in which pancreatic ferments are detected in the bile it should be possible to visualize the pancreatic duct by an x-ray examination following the injection of lipiodol into the biliary tract.

It has been our custom to do a routine visualization of the biliary tract in all cases of choledochostomy drainage. Of the thirty-five cases reported here, the pancreatic duct was not visualized in any of the

Fig. 1.

Figs. 1 and 2.—Case 1. Before administration of morphine (Fig. 1) the hepatic ducts are only terminally outlined before lipiodol enters the duodenum. This indicates a normal resistance of the sphincter of Oddi. Five minutes after morphine administration continued injection outlined the whole biliary tract and distended the common bile duct. In addition, the pancreatic duct (arrows) was outlined for a considerable distance.

twenty-five cases in which amylase was routinely absent from the bile. However, in the ten cases in which amylase was found in the biliary drainage, the pancreatic duct was visualized by lipiodol in seven (20 per cent). These results compare with the findings of Robins and Her-

manson,[18] who were able to visualize the duct in four out of twenty-five cases (16 per cent), and with those of Hunt, Hickson, and Best[19] (five cases out of fifty-six). Leven[20] found the duct visualized in 23 per cent of ninety-one cases.

The technique employed by us for visualization of the biliary tract is essentially as follows: About twelve days after operation iodized oil

Fig. 2.—See opposite page for legend.

is injected through the drainage T-tube into the biliary tract by means of a 50 c.c. syringe. Under fluoroscopic control the oil can be seen to enter the choledochus and fill the termination of the hepatic ducts. It then passes through the sphincter into the duodenum. Anteroposterior and lateral roentgenograms are taken at this point. If no organic obstruction is present in the choledochus, morphine sulphate, gr. 0.25, is given hypodermically, and five minutes later iodized oil is again injected. The entire biliary tract can be visualized before the iodized oil

is forced into the duodenum. Inasmuch as the abdominal orifice of the biliary fistula frequently overlies the region of the sphincter of Oddi, the patient should be turned over slightly to the right, in order to obtain an unobstructed view of the pancreatic duct.

If the pancreatic duct opens together with the common bile duct proximal to the spastic sphincter, the lipiodol invariably enters the duct of

Fig. 3.

Figs. 3 and 4.—Case 2. Injection of iodized oil showed definite spasm of the sphincter of Oddi (Fig. 3) since the hepatic ducts were outlined to a considerable extent before the oil passed into the duodenum. At the same time a portion of the pancreatic duct (arrow) was filled. The junction of the common and pancreatic ducts at the ampulla of Vater is clearly visualized. Note also the dilatation of the common bile duct. Following the administration of morphine (Fig. 4), the whole biliary tract is outlined. The increased tonicity of the duodenal wall as a result of morphine action caused compression of the intramural portion of both the common and pancreatic ducts. The ampullary junction of these ducts is, however, still clearly outlined (arrow).

Wirsung. Since the secretory pressure of the pancreas appears to be greater than the resistance of the sphincter of Oddi, only the terminal 5 to 7 cm. of the pancreatic duct can usually be visualized. Therefore,

in order to demonstrate the duct on the x-ray film, a steady continuous injection of lipiodol must be made while the plate is being exposed (Figs. 1 and 2). At times when the sphincter is sufficiently spastic, the pancreatic duct may be visualized even before morphine is given (Fig. 3). In such cases the administration of morphine may even decrease the visualization of the pancreatic duct (Fig. 4).

Fig. 4.—See opposite page for legend.

Two cases representative of the group in which pancreatic reflux occurred will be briefly presented:

CASE 1.—M. F., No. 407176, a 27-year-old male, was admitted to the wards of the Mount Sinai Hospital, April 15, 1937, and discharged June 3, 1937. The patient was well until ten months before admission, at which time he began to develop postprandial sensations of burning in the epigastrium, accompanied by a feeling of distention and substernal pain. This would begin usually fifteen minutes after a fatty meal and would last for the same length of time. Six days before admission the patient experienced localized epigastric and substernal pain, and two days later he noticed jaundice, clay colored stools, and dark urine.

Physical examination disclosed a jaundiced patient, not acutely ill. The abdominal examination was negative. The icteric index was fourteen, blood bilirubin 1.5 mg. per cent, cholesterol 319 mg. per cent, total, 115 mg. per cent ester. Bile was present in the urine, and the stool contained no urobilin. Galactose and sodium benzoate tests were done to rule out hepatitis. The galactose test gave an excretion of 3.5 gm., and the sodium benzoate, 3.13 gm., thus confirming the clinical impression of obstructive jaundice.

Under observation bile subsequently disappeared from the urine and urobilin was found in the stool.

Operation, which was performed April 21, 1937, revealed a chronically inflamed gall bladder containing a myriad of yellow cholesterol stones. It was adherent to the duodenum and transverse colon. The common duct was dilated and inflamed and contained many small cholesterol stones.

A retrograde cholecystectomy and a T-tube choledochostomy were performed.

Course.—Bile drained freely the next day. On the seventh day the bile drainage suddenly changed in character, and about 250 c.c. of a colorless fluid was collected. This was analyzed and found to contain 7,000 Elman units of amylase. This fluid did not digest egg white, indicating that the trypsin has not been activated. The biliary drainage was analyzed daily, as well as for a twenty-four-hour period for amylase, which was found in large concentration in all samples except those of the early morning and after breakfast. After two previous unsuccessful attempts, lipiodol visualization of the pancreatic duct was finally obtained after producing spasm of the sphincter of Oddi by the hypodermic administration of morphine (Figs. 1 and 2). The tube was removed on the thirty-ninth day, and the external bile drainage ceased immediately.

CASE 2.—S. M., No. 416038, a 52-year-old male, was admitted Oct. 30, 1937, and discharged Dec. 7, 1937. There was a history of right upper quadrant pain which often radiated to the left upper quadrant and into the back. The pain was relieved by belching and induced vomiting. There was no history of fever, chills, or jaundice. The present episode began six days before admission and was typical of previous attacks. The pain radiated from the right upper quadrant to the left upper quadrant and back.

The physical examination revealed a thin, middle-aged male. There were a few moist râles at the bases of both lungs. Tenderness and rigidity were present in the right upper quadrant of the abdomen, and a round ballotable mass was palpable in this region. Blood pressure was 140/84. There were 14,000 white blood cells, with 81 per cent polymorphonuclear leucocytes and 18 per cent lymphocytes. The urine was negative for bile. An x-ray plate of the abdomen revealed two ring-shaped concretions in the gall bladder region.

On Oct. 30, 1937, laparotomy was performed under spinal anesthesia, revealing an acutely inflamed hydropic gall bladder containing two large stones impacted in the ampulla. The common duct which was dilated to three times its normal size was the site of an acute inflammatory process and contained a small stone. A cholecystectomy and T-tube choledochostomy were performed.

Course.—The patient's postoperative course was complicated by bronchitis, but was otherwise uneventful. Bile drainage from the T-tube was positive for amylase. Determinations varied between fifteen and eighty-five units in twenty-four-hour samples for twelve consecutive days. Lipiodol x-ray films of the biliary tract visualized the major hepatic radicles without the use of morphine. The lipoidol could be seen passing into the pancreatic duct for a distance of about 10 cm. (Fig. 3). After the administration of morphine, the increased tonus of the duodenal wall partly obliterated the visualization of the intramural portion of both the choledochus and the pancreatic ducts (Fig. 4). However, the ampulla at the junction of these two ducts was clearly visible. On the thirty-seventh day, the T-tube was tied off.

At that time the sphincter resistance measured about 150 mm. After clamping the tube for five days, the resistance of the sphincter was found to be 90 mm. The tube was removed and the fistula closed immediately.

The ten patients in whom amylase was found in the choledochostomy drainage had histories in no wise different from the other twenty-five patients in whom no pancreatic reflux was present. Following the removal of the drainage tubes the fistula closed up promptly in each patient. Subsequent follow-up studies, in some as long as three years, did not reveal any residual symptoms or give any indications that the finding of pancreatic reflux was of any prognostic significance. These findings are similar to those reported by Popper.

DISCUSSION

The demonstration that between 20 and 30 per cent of patients with choledochostomy tube drainage have a pancreatic reflux is not purely of academic interest but has marked clinical implications. The evidence is quite clear that patients with an intact biliary tract can develop acute cholecystitis, often in association with nonperforative bile peritonitis, as a result of a reflux of pancreatic juice into the gall bladder. Similarly, acute pancreatitis often occurs following the reflux of bile into the pancreatic duct. The suggestion that chronic cholecystitis and choledochitis, with or without the presence of stones, may result from such intermittent pancreatic reflux has been brought forward by a number of investigators.[21] Wolfer[22] actually produced chronic cholecystitis experimentally by continual reflux of pancreatic juice into the gall bladder. The evidence, however, that some of the cases of chronic cholecystitis and cholelithiasis in man might be due to such a mechanism has so far remained unproved.

Pancreatic enzymes were not found by us in any sample of bile obtained from the gall bladder in cases of chronic cholecystitis. All these, however, were interval operations in which the patients were given a very light diet for the previous twelve to eighteen hours. Periodic examination through the day in our cases of pancreatic reflux showed that in the absence of food ingestion pancreatic reflux did not occur, since the pancreas was not secreting pancreatic juice. It is possible then that the absence of pancreatic enzymes in the bile of our patients with chronic cholecystitis did not in any way preclude the possible presence of pancreatic reflux in a certain number.

It was extremely interesting to observe the reflux of varying amounts of pancreatic juice in those patients in whom the pancreatic duct emptied into the choledochus above the sphincter of Oddi. A slight degree of sphincter spasm would be shown by the presence of small amounts of amylase in the biliary drainage. Severe sphincter spasm would result in a flow of pale clear bile containing a large concentration of amylase. In all these cases organic obstruction was completely absent, functional spasm alone being sufficient to cause pancreatic reflux.

SUMMARY

1. The incidence of pancreatic reflux in 35 consecutive cases of choledochostomy drainage was 28.5 per cent, as evidenced by the presence of significant amounts of amylase in the bile. In this latter group of 10 cases the pancreatic duct was visualized, in 7 or 70 per cent, after the injection of iodized oil into the biliary tract.

2. In 4 out of 14 cases of acute cholecystitis without cystic duct obstruction pancreatic enzymes were found in large concentration in the gall-bladder bile. The absence of pancreatic enzymes in the gall bladder in cases of chronic cholecystitis does not preclude the possibility of pancreatic reflux in these patients.

3. Spasm alone of the sphincter of Oddi is sufficient to cause pancreatic reflux.

REFERENCES

1. Opie, E. L.: The Etiology of Acute Hemorrhagic Pancreatitis, Bull. Johns Hopkins Hosp. **12**: 182, 1901.
2. Archibald, E.: The Experimental Production of Pancreatitis in Animals as a Result of the Resistance of the Common Duct Sphincter, Surg. Gynec. & Obst. **28**: 529, 1919.
3. Letulle, M., and Nattan-Larrier: Region vaterienne du duodenum et ampoule de Vater, Bull. Soc. anat. de Paris **12**: 491, 1898.
4. Ruge, E.: Beitrage zur chirurgischen Anatomie der grossen Gallenwege, Arch. f. klin. Chir. **87**: 47, 1908.
5. Opie, E. L.: Diseases of Pancreas, ed. 2, p. 15, 1910, J. B. Lippincott Company.
6. Baldwin, W. M.: The Pancreatic Ducts in Man Together with a Study of the Microscopical Structure of the Minor Duodenal Papilla, Anat. Rec. **5**: 197, 1911.
7. Osler, W.: Osler's Modern Medicine **5**: 637, 1908.
8. Schmieden, V., and Sebening, W.: Surgery of the Pancreas, Arch. f. klin. Chir. **148**: 319, 1927.
9. Judd, E. S.: Relation of Liver and Pancreas to Infection of the Gall Bladder, J. A. M. A. **77**: 197, 1921.
10. Mann, F. C., and Giordanno, A. S.: The Bile Factor in Pancreatitis, Arch. Surg. **6**: 1, 1923.
11. Cameron, A. L., and Noble, J. F.: Reflux of Bile up the Duct of Wirsung Caused by an Impacted Biliary Calculus, J. A. M. A. **82**: 1410, 1924.
12. Nordmann, O.: Experimente und klinische Betrachtungen über die Zusammenhange zwischen acuter Pankreatitis und Erkrankungen der Gallenblase, Arch. f. klin. Chir. **102**: 66, 1913.
13. Westphal, K.: Die durch Dyskinese der Ausfuhrungsgange bedingten Pankreasferment schadigungen an den Gallenwegen und der Leber, Ztschr. f. klin. Med. **109**: 55, 1928.
14. Colp, R.: Calculous Obstruction of Common and Hepatic Bile Ducts, Ann. Surg. **86**: 890, 1927.
15. Popper, H. L.: Pancreatic Juice in the Bile Ducts. Its Pathogenic Significance in the Origin of Acute Pancreatic Disease, Arch. f. klin. Chir. **175**: 160, 1933.
16. Elman, R., Arneson, N., and Graham, E. A.: Value of Blood Amylase Determination in the Diagnosis of Pancreatic Disease, Arch. Surg. **19**: 943, 1929.
17. Colp, R., Gerber, I., and Doubilet, H.: Acute Cholecystitis Associated With Pancreatic Reflux, Ann. Surg. **103**: 67, 1936.
18. Robins, S. A., and Hermanson, L.: Cholangiography: Modified Technique for X-Ray Visualization of the Bile Ducts During Operation, Surg. Gynec. & Obst. **62**: 684, 1936.
19. Hunt, H. B., Hickson, N. F., and Best, R. R.: Exploration of the Biliary Ducts by Cholangiography During and Following Operation, Am. J. Roentgenol. **38**: 542, 1937.
20. Leven, N. L.: Personal communication.
21. Wolfer, J. A.: Pancreatic Juice as a Factor in the Etiology of Gall Bladder Disease, SURGERY **1**: 928, 1937.
22. Wolfer, J. A.: The Role of the Pancreatic Juice in the Production of Gall Bladder Disease, Surg. Gynec. & Obst. **53**: 433, 1931.

PATHOLOGIC CHANGES IN CHRONIC CHOLECYSTITIS AND THE PRODUCTION OF SYMPTOMS

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THE symptoms most commonly encountered in chronic cholecystitis consist of pain either as biliary colic or as a constant pain in the upper right quadrant or beneath the right shoulder blade, nausea, vomiting, dyspepsia of a selective type, and jaundice. This syndrome has been encountered so often in inflammation of the biliary tract that we expect to find pathologic changes in the gall bladder whenever it occurs. Likewise it is a common expectation for the patient to show considerable relief from these symptoms following removal of the gall bladder. This knowledge has been established empirically based on a vast surgical experience of more than a generation of surgeons. When one considers the enormous amount of work that has been published relating to diseases of the gall bladder, one is impressed by how little has been accomplished in an effort to explain the origin of these symptoms. Such information is important, for a more rational basis for the explanation of this syndrome might make the choice of cases for cholecystectomy easier with a better promise for the relief of symptoms.

The present study deals with patients in whom pain, nausea, and vomiting were outstanding symptoms. These patients for the most part had very definitely diseased gall bladders, many of which contained stones. Because of the obvious relationship of pain, nausea, and vomiting to the visceral nervous mechanism of the gall bladder, it seemed likely that it would be of some value to study the nerves seen in random sections of the gall-bladder wall. Sections were routinely taken from the fundus and neck of the gall bladder. They were stained with hematoxylin and eosin and on occasions with Mallory's orange G—aniline blue stain. Evidence of the involvement of nerve fibers in exudative or reparative inflammatory processes was sought.

The gall bladder is supplied by both sympathetic and parasympathetic fibers. Pain fibers follow the sympathetic pathways (1) having synapses in the celiac ganglion and extend along the greater splanchnic trunks entering the cord in the midthoracic region. Apparently the majority of these fibers are located in the right trunk. Both motor and sensory fibers extend through the vagal pathways, some of which pass directly through the celiac ganglia. Beneath the muscularis in the wall of the gall bladder one often encounters single ganglion cells

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and at other times relatively large ganglia (Fig. 1). These probably represent vagal pathways. The pain fibers to the biliary tract extend along the hepatic and cystic artery as has been shown by Moore.[2] These fibers extend through the musculature and apparently terminate in the mucosa or possibly between the epithelial cells of the mucosa. These fibers have no specialized endings but terminate as exposed, raw nerve fibers. Fig. 2 illustrates a nerve bundle traversing the wall of a gall bladder before it breaks into its radicles to perforate the muscularis. It can be easily noted that surrounding this nerve bundle

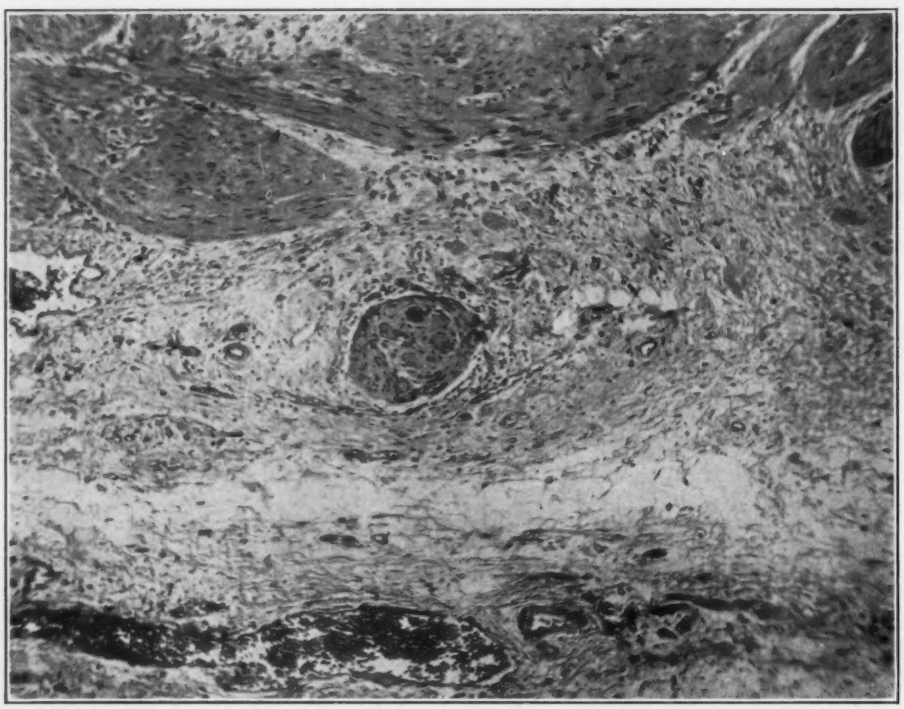

Fig. 1.—Large ganglion beneath the musculature of a slightly damaged gall bladder. There is a moderate amount of fibrosis and round cell infiltration. This ganglion is probably parasympathetic.

there is a considerable amount of loose areolar connective tissue. The gall-bladder wall is relatively normal, containing only a slight increase in lymphocytes.

The pathologic changes associated with nerves of the gall bladder consist for the most part of fibrosis and inflammation. Fig. 3 illustrates the type of inflammatory reaction that is often seen associated with nerve trunks. The cellular reaction is chiefly lymphocytic and monocytic in type and can be seen surrounding several fairly large nerve trunks. Strangely enough this type of lymphocytic reaction is often seen only around the nerve. This may be due to the close proximity of the nerve trunks to the lymph channels. Such an area of inflammation around a peripheral nerve is not uncommonly asso-

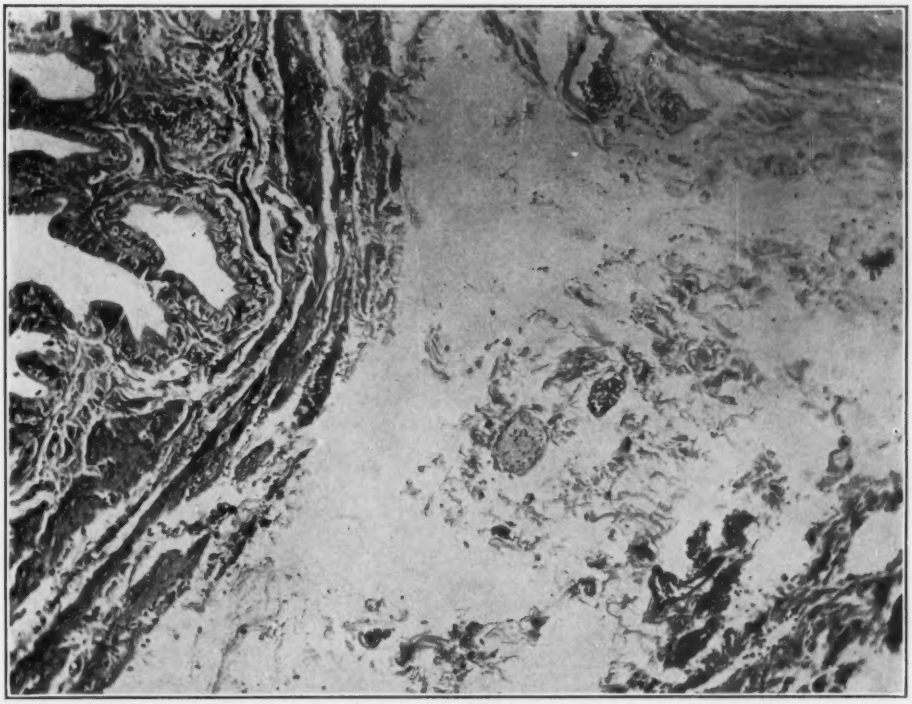

Fig. 2.—Nerve trunk in the wall of a normal gall bladder. Note the loose areolar tissue surrounding the nerve.

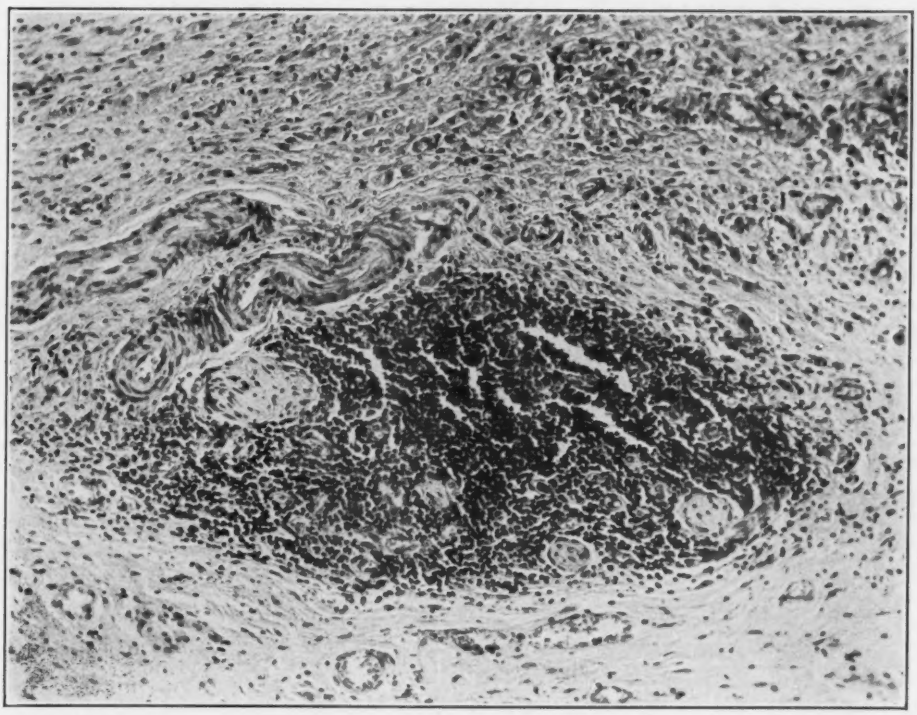

Fig. 3.—Nerve trunks surrounded by an area of extensive round cell infiltration. There is a considerable amount of fibrosis present.

ciated with increased irritability on the part of the nerve. It must be borne in mind that not only can the nerve endings be stimulated but the nerve trunks as well. Fig. 4 shows two nerve trunks that have extended almost to the mucosa. Again one sees a considerable amount of inflammatory reaction as well as fibrosis. Such a change is likewise seen in Figs. 5 and 6. Instances were often encountered in which most of the lymphocytic reaction in the wall of the gall bladder had disappeared and in its place there was left only dense fibrous tissue. When nerve trunks become involved in such fibrous tissue, they are often difficult to identify. Such changes were noticed

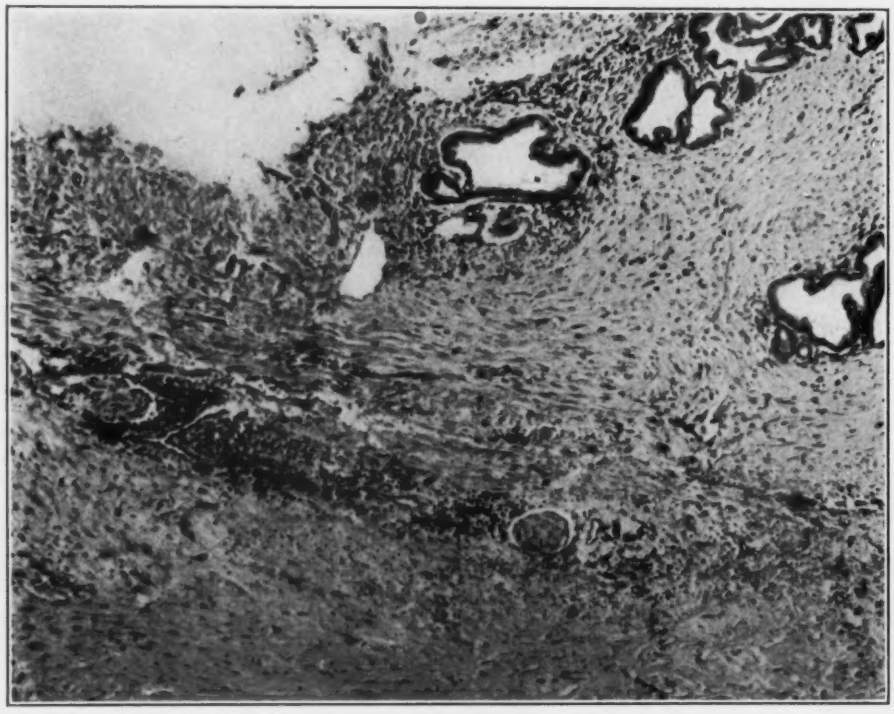

Fig. 4.—Nerve trunk extending through dense fibrous tissue and adjacent to round cell infiltration.

in the nerves of the appendiceal wall several years ago by Masson who described them in great detail.[3] Fig. 7*A* illustrates a type of change. It is noteworthy here that the nerve is breaking up into numerous smaller bundles such as is seen in the so-called amputation neuroma. Fig. 7*B*, taken from the same region, shows these adventitious bundles surrounded by dense collagenous intercellular tissue formed by fibroblastic proliferation.

Studies described in the preceding paragraph are from gall bladders from patients who complained severely of the symptoms of pain, nausea, and vomiting. The blocks were cut at random with no effort being made to place the section in the region of nerves. While sec-

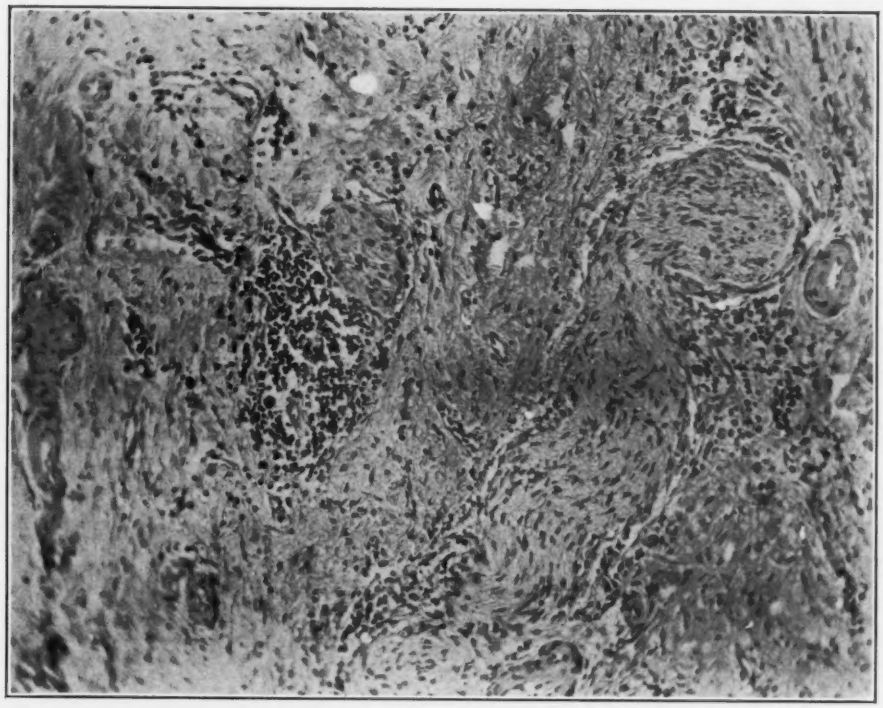

Fig. 5.—Nerve trunk following a tortuous course through dense fibrous tissue with a small amount of persisting inflammatory reaction.

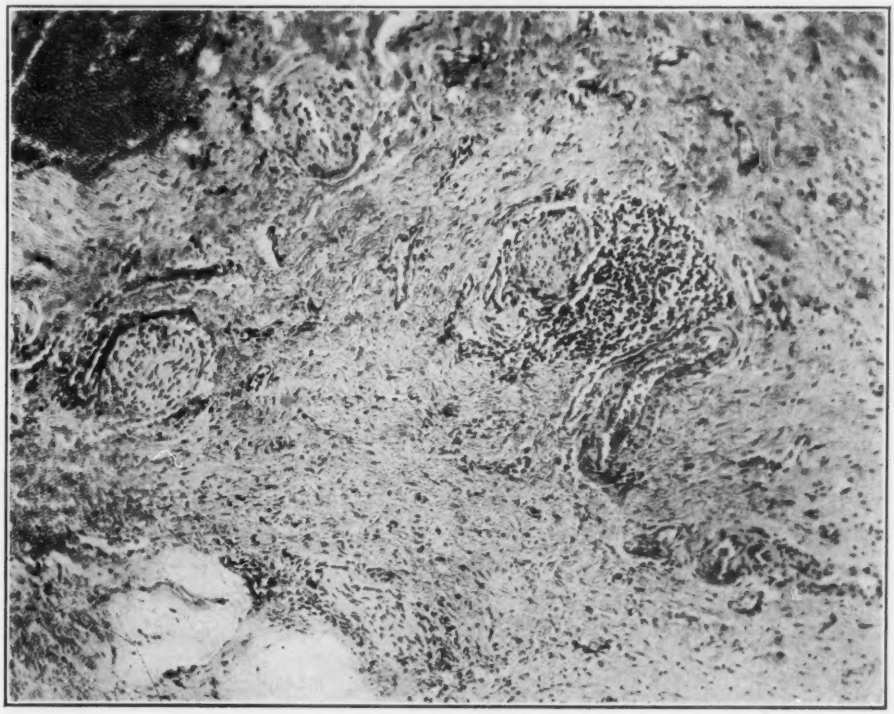

Fig. 6.—Fibrosis and round cell infiltration around nerve trunks in the wall of a damaged gall bladder.

tions taken in this way have not always showed the changes described, nevertheless it has been possible frequently to demonstrate such pathologic changes in the nerves in gall bladders in which there have been inflammatory change or marked increase in fibrous tissue.

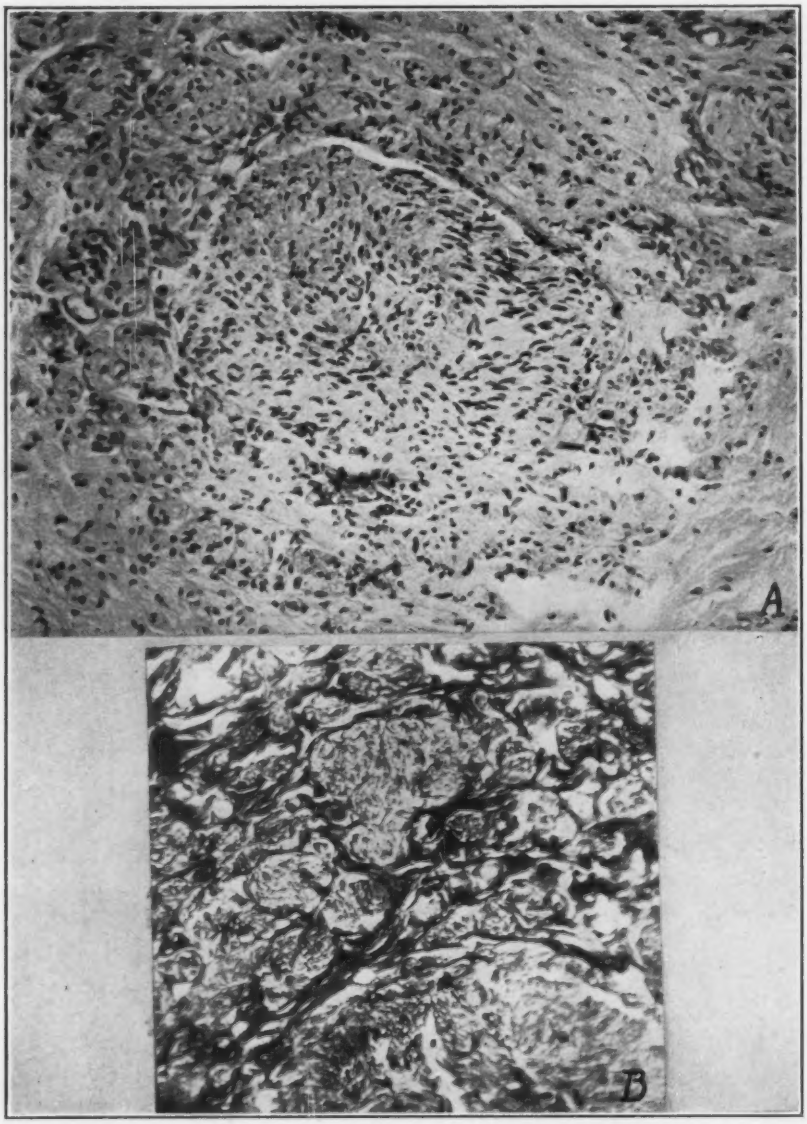

Fig. 7.—*A*, Cross section of a nerve trunk at the neck of a gall bladder showing fragmentation and splitting off of small groups of fibers such as is generally seen in an amputation neuroma; *B*, area taken from *A* stained with Mallory's orange G and aniline blue stain to show the extensive amount of fibrosis between the nerve bundles.

DISCUSSION

Visceral sensory nerves may be stimulated by stretching, inflammation, or ischemia. Often there is a combination of two or three of these factors at the same time. The production of pain by the stretch-

ing of visceral nerves is a frequent observation clinically when the mesentery is pulled upon during an operation under local anesthesia and during spasm of smooth muscles. The explanation of pain in inflammation is one that still requires further study. It is quite possible that edema may play some part in itself by stretching the nerve, or that certain substances liberated or formed by the inflammatory process stimulate pain fibers. The throbbing pain frequently felt in acute inflammations of the extremities is probably a result of stretching of the nerves by the forcing of blood into the area with each pulse beat. An interesting observation is that recently reported upon by Moore[2] in which he noted that the potassium ion, even in isotonic solution, was markedly irritating to both pain endings and pain fibers. In stressing this fact he called attention to the recent observations in which a deposition of potassium ions has been noted in the intercellular fluids of inflammatory exudates.[4] The factor of ischemia is an old one. The observation of pain during sudden occlusion of an artery, due either to spasm or embolus, is well recognized. That the accumulation of acid bodies in the tissues following ischemia might be instrumental in the production of pain has been previously noticed. That this actually does take place in the case of lactic acid has been more recently demonstrated.[2]

The pathologic changes that have been demonstrated about the nerves in the wall of badly damaged gall bladders are such that would tend to increase the tension on nerves and to decrease the amount of blood supply. The factors then of stretching and ischemia must be considered seriously wherever there is marked fibrosis around the nerve trunks. If these factors are not in themselves sufficient to produce pain, they undoubtedly will alter the threshold of stimulation to such an extent that stimuli which otherwise would not be apparent become noticeable. This same reasoning applies to the presence of inflammatory changes around nerve fibers. Inflamed areas are notably tender. At times slight pressure exerted on a localized region of inflammation will produce excruciating pain that normally would hardly reach the level of consciousness.

The effect of a given stimulus upon the nerves of the gall bladder will depend not only upon the irritability of these nerves but upon the number of the nerves present and upon the strength and repetitiveness of the stimulation. It is a well known clinical observation that the normal sensibility of the upper right quadrant is greater than that of most other parts of the abdomen, probably due to a considerable extent to the presence of a larger number of pain fibers. The stimulus probably the most commonly encountered in biliary tract disease is that of increased intracystic or intraductal pressure either due to abnormal closure of the sphincter Oddi or due to spasm of the sphincter or duodenum or some other portion of the biliary tract. The

association of the appearance of pain, nausea, and vomiting with increase in intraductal pressure has been noted by Schrager and Ivy[5] and by Davis, Hart, and Crain.[6] They found that distention of the cystic duct and bile ducts in the dog was associated with pain, nausea (salivation), and vomiting. The same observation has subsequently been made in the human by McGowan, Butsch, and Walters[7] and by Doubilet and Colp.[8] If the same factors involved in the irritability of pain fibers are applied to motor fibers, it is quite obvious that increased irritability of the motor nerve must also be present. If this is true, where such lesions as we have demonstrated are present, one would expect to encounter more frequently crises due to a sudden increase in intrabiliary tract pressure as a result of muscle spasm.

With the advent of cholecystography it was hoped that earlier changes in the wall of the gall bladder would be detected and, as a matter of fact, this has been found to be the case. That the failure of normal visualization of the gall bladder during cholecystography was not necessarily associated with the production of symptoms was early noted and on numerous occasions stressed by the originators of cholecystography. Unfortunately this fact has at times been lost sight of and too often the gall bladder has been removed not on the basis of the clinical history or pathologic findings but purely on the basis of abnormal visualization. While it is true that the most common cause of failure of visualization of the gall bladder is marked pathologic changes in the wall of the gall bladder, this is not necessarily the case as Graham and his coworkers have often stressed.

As a general rule, cholecystitis without the presence of stones or cholesterolosis of the gall bladder with stones and without much damage in the wall of the gall bladder represents relatively early lesions. Recently Mackey[9] reviewed a series of Barnes Hospital patients with noncalculous choleystitis and cholesterolosis, analyzing the end results in relation to the local pathologic lesion, the history of the patient, and cholecystographic visualization. From his results it seems obvious that those patients experience a greater relief from their symptoms after cholecystectomy who have definite fibrotic and inflammatory changes in the wall of the gall bladder and in whose cases the history of biliary colic is outstanding. Such patients seemed to have been relieved almost in direct proportion to the amount of pathologic damage seen in the wall of the gall bladder. The exceptions to this were those with cholesterolosis of the gall bladder with stone. However, in cholesterolosis when stones did not exist, marked improvement was present only in approximately one-half of the cases. Most of those patients that showed improvement likewise showed nonvisualization of the gall bladder.

It is interesting to consider what takes place when the gall bladder is removed that causes a disappearance of symptoms if those symptoms

are explained on the mechanism that we are suggesting. Perhaps one of the most important factors would be the removal of a large number of nerve fibers and nerve endings so that a given stimulus would not have the same marked effect. Another important occurrence is the removal of a considerable amount of the inflamed tissue, allowing the rest of the biliary tract a chance to recover. A third factor is the removal of a number of the causes of spasm such as stones and nerves with a lowered threshold of stimulation that have to do with the motor function of the biliary tract. In those patients with severe gall-bladder disease, who are not completely relieved of their symptoms, it is interesting to theorize upon what the mechanism might be. It is conceivable that if there is a sufficient amount of nerve damage around the common duct, the symptoms may still persist. If only a small proportion of the involved nervous mechanism is left, then it is quite possible that a few of the minor symptoms would persist such as may be due to slight changes in motility of the gastrointestinal tract as in dyspepsia and nausea.

CONCLUSION

In chronic cholecystitis in which there are generally seen marked inflammatory changes in the wall of the gall bladder and in which the patient exhibits a considerable amount of pain, nausea, and vomiting, it is very easy to demonstrate pathologic changes in and around the nerve fibers of the gall bladder. These changes, for the most part, consist in fibrosis and inflammation producing stretching, ischemia, and the local effects of inflammation around the nerve fibers and endings. These factors either actually produce pain or else so lower the threshold of stimulation that stimuli normally not apparent to the individual result in marked symptoms. Following cholecystectomy many nerve fibers as well as the above-mentioned lesions are removed with a subsequent improvement in the clinical condition of the patient. Characteristic lesions are shown.

REFERENCES

1. Kuntz, A.: The Autonomic Nervous System, Philadelphia, 1934, Lea and Febiger.
2. Moore, Robert M.: Some Experimental Observations Relating to Visceral Pain, SURGERY 3: 534, 1938.
3. Masson, P.: Neural Proliferations of the Vermiform Appendix, Cytology and Cellular Pathology of the Nervous System, W. Penfield, Vol. III, 1097, New York, 1932, Paul B. Hoeber.
4. Hübler, C., and Hummel, R.: Über die Schmerzauslössende Wirkung des K-ions, Klin. Wchnschr. 7: 2151, 1928.
5. Schrager, V. L., and Ivy, A. C.: Symptoms Produced by Distension of the Gallbladder and Biliary Ducts, Surg., Gynec. & Obst. 47: 1, 1928.
6. Davis, Loyal, Hart, J. T., and Crain, R. C.: The Pathway for Visceral Afferent Impulses Within the Spinal Cord, Surg., Gynec. & Obst. 48: 647, 1929.
7. McGowan, J. M., Butsch, W. L., and Walters, W.: Pressure in the Common Bile Duct of Man, J. A. M. A. 106: 2: 2227, 1936.
8. Doubilet, H., and Colp, Ralph: Resistance of Sphincter of Oddi in the Human, Surg., Gynec. & Obst. 64: 622, 1937.
9. Mackey, W. Arthur: Cholecystitis Without Stone, Brit. J. Surg. 22: 86:274, 1934.

A SURGICAL PROCEDURE FOR HYDROCEPHALUS ASSOCIATED WITH SPINA BIFIDA*

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A REVIEW of the literature reveals a wide discussion of the results of surgery for the repair of spina bifida. With excision of the sac, the operative mortality reported with few exceptions has been high,[1] averaging in the neighborhood of 50 per cent.[2] The additional mortality from secondary causes during the first year further increases the total mortality to a considerable extent. With preservation of the sac, as advocated by Penfield and Cone,[3] and with improved postoperative care, the operative mortality has been lowered and death from secondary causes reduced.[4] However, hydrocephalus still remains one of the chief secondary causes of death. This hydrocephalus, with few exceptions, is associated with myelomeningocele, while with the meningocele it is rarely seen. It is also well known that both the operative mortality and the mortality during the first year is very low for the meningocele but quite high for the myelomeningocele. This relationship of hydrocephalus and high mortality to myelomeningocele seems significant and deserves special attention.

The sac has been commonly considered as a safety valve because its removal is so often immediately followed by hydrocephalus. Penfield and Cone maintain that the sac functions as a mechanism for the transmission of cerebrospinal fluid into the blood stream and that hydrocephalus will not be precipitated if the sac is conserved. While practically all attention has been focused on the sac in interpreting the mechanism of hydrocephalus, little surgical consideration has been given to other pathologic findings which have been found associated with spina bifida.

ANATOMIC FINDINGS

Associated with the myelomeningocele in particular is found a malformation of the hind brain first described by Arnold[5] in 1894 and again in the year following by Chiari.

Russell and Donald[6] in 1935 published a comprehensive report on the post-mortem findings of ten consecutive cases of myelomeningocele and from these findings they deduced an explanation for the hydrocephalus. In all these cases the Arnold-Chiari malformation was found. A tongue consisting of cerebellar tissue and elongated medulla oblongata was observed. These projections extended for varying distances down the verte-

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bral canal overlapping and compressing the upper segments of the spinal cord. The fourth ventricle was found to lie largely in the vertebral canal and here the cerebellar prolongation formed the roof and the medullary component the floor. The foramina leading from the fourth ventricle were situated extracranially a considerable distance below the foramen magnum. In one case these were imperforate. The leptomeninges overlying the malformation were thickened and quite vascular. In all cases the cervical roots coursed cephalad to reach their dural exits. There was a hypoplasia of the cerebellum and an elongation of the pons and medulla. One less marked malformation associated with a meningocele was described.

Two of the cases in the series reported here were examined at postmortem examination, one after an operative death and the other one year later, following death from epidemic meningitis. Both cases showed the essential findings of the Arnold-Chiari malformation as described (Fig. 1), and in addition showed marked hydrocephalus.

DISCUSSION OF THE ROLE OF THE MALFORMATION

A consideration of these abnormal findings situated as they are at a crucial point in the cerebrospinal circulation would readily indict them as a major causative factor in the formation of hydrocephalus in these cases. The fact that the malformation has been found to be absent or little developed in cases with a meningocele, together with the fact that hydrocephalus is rarely associated with this type, seems to further establish it as a major causative factor.

These pathologic findings suggest a surgical approach to the malformation with the hope of re-establishing a normal cerebrospinal fluid circulation. C. J. van Houweninge Graftdijk[7] in a monograph presented in 1932 contended that the malformation acted as a valve allowing the cerebrospinal fluid to pass upward into the cerebral subarachnoid spaces but obstructing its flow from the ventricles into the vertebral canal. He attempted to relieve the obstruction by operation, but death followed and no clinical conclusions could be drawn. Russell and Donald, on the basis of their pathologic studies, believe that where the foramina of Luschka and Majendie are patent cerebrospinal fluid escapes into the vertebral canal but is hindered in its passage upward into the cerebral subarachnoid channels by the Arnold-Chiari malformation plugging the upper cervical canal. This, they believe, leads to a damming back of the cerebrospinal fluid in the ventricular system resulting in internal hydrocephalus.

Examination of the malformation by surgical exposure gives further information as to its relation to the hydrocephalus and the mechanism that operates. In six consecutive cases of myelomeningocele reported in this series, hydrocephalus developed. Operation showed the Arnold-Chiari malformation to be present in every case. On exposure of the

dura over the upper segments of the cord it was found to be distended and in some instances fusiform in shape, narrowing considerably at the foramen magnum and again at a variable distance below at a level determined by the extent of the malformation. Opening of the dura showed this enlargement to be due to the compressed contents consisting of prolongations of cerebellum and medulla, and a distended subarachnoid space over the lower part of the malformation. The upper part, espe-

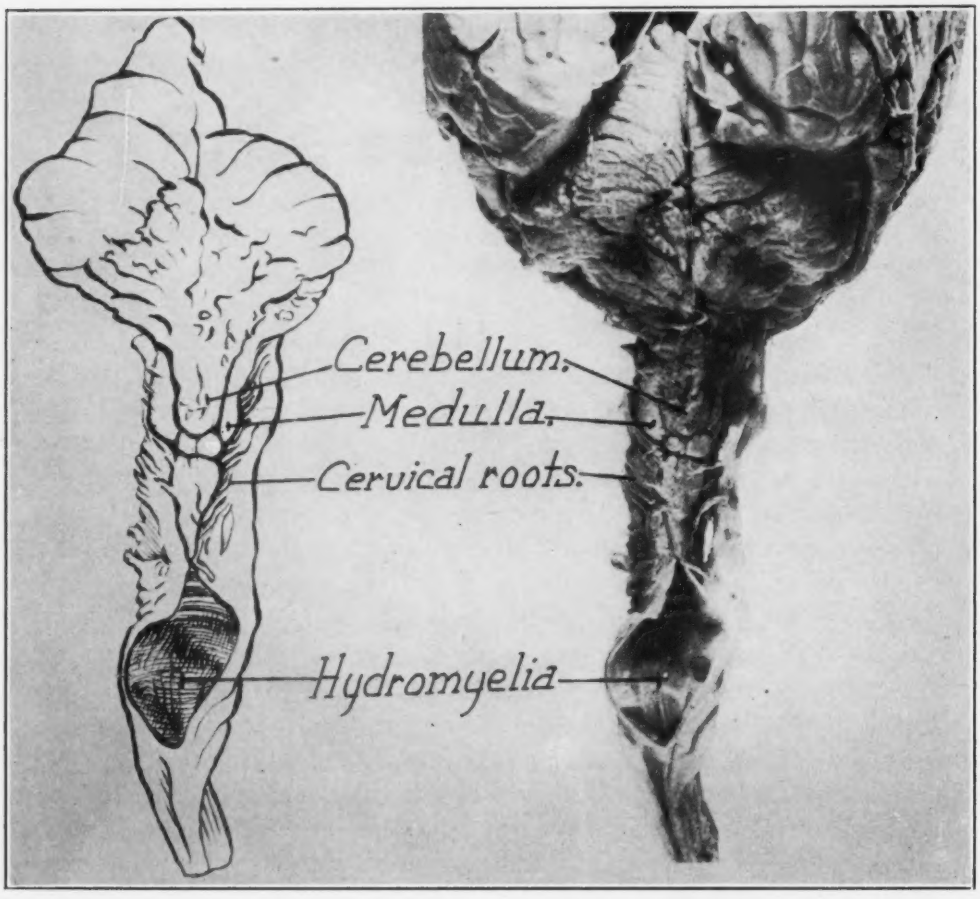

Fig. 1.—Outline drawing of malformation in Case 5 and photograph from which outline was taken. Characteristic features of the malformation are shown.

cially in the region of the foramen magnum, was invariably covered by fibrous thickened meninges which were bound by numerous adhesions to the adjacent dura. In most instances the cisterna magna was largely obliterated by this process. No subarachnoid fluid could be seen in these thickened meninges and it seemed evident that the subarachnoid channels were reduced. The amount of compression was variable and it appeared likely that several mechanisms of obstruction could operate.

In two cases in which the suboccipital operation was performed first, the sac was observed during the tapping of the lateral ventricles pre-

liminary to operation. With removal of the ventricular fluid, the tension of the sac was immediately lowered and its size reduced. This indicates only communication of the ventricular system with the spinal subarachnoid space. It is possible that, by reducing the intracranial pressure, compression at the site of the malformation may be relieved and the fluid channels which were previously collapsed restored. In several cases during operation the cerebrospinal axis was slightly inclined with the head uppermost. The dura was first opened well below the foramen magnum and on making a small opening into the subarachnoid space free and continued flow of fluid was obtained. This was presumably from the intracranial cavity as was indicated by a reduced pressure reading from the lateral ventricle following this drainage. This finding substantiates the idea that one mechanism producing the hydrocephalus is an obstruction of the return flow between the subarachnoid channels of the vertebral canal and those of the subtentorial fossa.

The appearance of the leptomeninges at operation is quite striking. Immediately on opening the dura over the malformation an increased vascularity of the leptomeninges is seen with marked injection of the pial vessels, especially in the region of the foramen magnum. In some instances free blood was observed matted in the arachnoid, similar to that seen after contusion of the cortex. These findings suggest mechanical irritation as a cause for the thickening and the adhesions of the meninges. While compression of the subarachnoid channels from the added mass of the malformation appears to be a major factor, obliteration by fibrosis may very well play a considerable part in the obstruction of the fluid flow. Other obstructions which may occur are compression of the fourth ventricle and closing off of the foramina of exit. Operation was considered as a feasible measure to promote the cerebrospinal circulation as far as the available channels would allow.

OPERATION

After preliminary ventricular puncture, a midline incision of sufficient length is made from the occipital protuberance downward to expose the occipital bone and the laminae of the first, second, and third vertebrae. The muscles are then cleared well laterally from the occipital bone and from the laminae of the first three cervical vertebrae. Ample exposure is made possible by small transverse incisions into the muscles of either side. The occipital bone thus exposed is rongeured away and the laminae of the first and second vertebrae removed close to the articular facets. The dura is then opened widely throughout the extent of the bone defect. The malformation is often found to extend to a lower level and in this event the wound is extended downward and additional laminae are removed until the whole lesion is exposed. Numerous adhesions are found binding the thickened leptomeninges to the dura and these are dissected free close to the dura to avoid injury to the arachnoid and the

underlying vessels. Dissection is carried anteriorly as far as possible toward the region of the anterior cisterns. The dura is left widely open to allow for decompression and to promote filling of the fluid channels. The wound is closed in layers with interrupted sutures of silk. Resection of any part of the malformation has not seemed justified and no attempt has been made as yet to establish a new opening into the fourth ventricle.

REPORT OF CASES

CASE 1.—D. R. W., a male infant, was seen on July 20, 1935, several hours after birth with a large spina bifida of the lower lumbar region. There was a complete paralysis of the lower extremities and relaxation of the sphincters. The membrane was very thin and on the third day there was an opening in the sac which necessitated immediate repair. Circumference of the head at this time was 33 cm. The sac was dissected free and a number of roots of the cauda equina were found attached to it. After closure of the sac, it was folded, and flaps of fascia from the adjacent muscles were imbricated over it. By the fifth day after operation the fontanelles had become quite tense and the circumference of the head had increased to 35 cm. The patient was discharged on Aug. 3, 1935, the eleventh postoperative day. The circumference at this time was 35.7 cm. One week following discharge, the circumference had increased to 36 cm. and one week following that to 37.7 cm. On August 28, 1935, the head measured 38.2 cm. and on this day suboccipital exploration was done. Ventricular puncture was first done and this showed an obvious hydrocephalus. A midline incision about 7 cm. long was then made extending downward from the occipital protuberance. This was carried to the occipital bone and the arches of the first three cervical vertebrae. The occipital bone was ronguered well laterally and the posterior border of the foramen magnum and the arches of the first three cervical vertebrae were removed. The dura exposed showed marked constriction at the foramen magnum with a fusiform dilatation below. On opening the dura the malformation was exposed extending just beyond the third lamina. Over the lower part an excessive collection of subarachnoid fluid was observed bulging beyond the borders of the dura. The leptomeninges over the upper part of the malformation were thickened and the cisterna magna was obliterated over a large portion of its extent. Adhesions to the dura were found in the region of the foramen magnum and just below. These were freed laterally and as far forward as possible. The dura was left open throughout the extent of the bone defect for decompression. The patient did not stand the procedure well and did poorly for the first forty-eight hours. At the end of that time, he showed a marked change for the better and continued to improve throughout the convalescence. At the end of one week the head had not increased in size and on discharge, Sept. 9, 1935, the twelfth postoperative day, the head measured 38.8 cm. in circumference. Ten days later measurements showed no increase in size. On Oct. 4, 1935, the circumference was 39.5 cm. Subsequent measurements are as follows: Nov. 27, 44.6 cm.; Jan. 14, 1936, 46 cm.; April 7, 48.5 cm.; July 29, 48.8 cm.; Dec. 29, 50.5 cm.; March 9, 1937, 50.5 cm.

CASE 2.—L. P., a male infant, was seen on Dec. 3, 1935, one day after birth with a spina bifida of the lumbar region. The sphincters were relaxed and there was a marked paralysis and clubfoot deformity in each lower extremity. At the end of two months the fontanelles and sac became tense and on Feb. 27, 1936, the spina bifida defect was repaired. On this date the head measured 38.5 cm. The sac was multilocular and many roots were attached to it. After suturing it was folded and covered with flaps of fascia from the adjacent muscles. By the fourth postopera-

tive day the head measured 39.5 cm. in circumference. The patient made an uneventful recovery and was discharged thirteen days after operation. At the time of discharge the fontanelles were somewhat tighter than on admission and the head measured 40.5 cm. On March 31 the head measured 43.5 cm. and on this day a suboccipital exploration was done. Through a midline incision the occipital bone was ronguered to either side and the posterior border of the foramen magnum and the arches of the first two vertebrae were removed. On opening the dura widely, the malformation was found to extend beneath the arch of the third cervical vertebra and this also was removed. The leptomeninges showed marked thickening. At the level of the foramen magnum there was an apparent compression ring. Over the malformation and extending somewhat above the foramen magnum there was a definite injection of the arachnoid with apparently a slight amount of free blood just beneath the surface. Dissection of rather dense adhesions was carried laterally and as far forward as possible toward the anterior cisterns. The patient made a good recovery and was discharged on the ninth postoperative day. The head at this time measured 43.5 cm., the same circumference as on the day of admission. During the six months following, the circumference had gradually increased in size to 47 cm. On Dec. 7, nine weeks later, the circumference was measured at 48 cm. On Feb. 15, 1937, the circumference was 49 cm. For one month following this there was no further growth and at the end of this time the patient expired following a middle ear infection with secondary intracranial involvement. Post-mortem examination was done. This showed purulent otitis media and an acute purulent leptomeningitis. Gram-negative intracellular diplococci were recovered from the spinal fluid.

CASE 3.—N. R. W., a female infant, was first seen on Jan. 6, 1936, three weeks after birth. Examination at this time showed a large lumbar myelomeningocele which was infected. The infant had fever of 103° at the time, was cyanotic, and had convulsive seizures with drawing of the head backward and extension of the extremities. The infection was treated and the symptoms quickly subsided. On March 2, 1936, the wound was entirely healed and the patient was free of symptoms and had gained in weight. The head at this time measured 40.7 cm. The spina bifida defect was repaired the following day. After dissecting the sac free, it was opened and the cord and numerous roots were found attached to it. After suturing the sac, it was bundled and covered with the fascia of the adjacent muscles, according to the method of Penfield and Cone. An uneventful recovery followed and the patient was discharged on March 15, 1936. The head at this time measured 40.7 cm., the same circumference as on admission. Within two weeks the circumference had increased 2 cm. On April 28, 1936, a suboccipital exploration was done. The head then measured 45.5 cm. After preliminary ventricular puncture, the usual suboccipital defect was made and the arches of the first three vertebrae were removed in order to expose the entire lesion. The cisterna magna was largely obliterated and dense adhesions which bound the leptomeninges to the overlying dura in this region were dissected free. The typical extensions of cerebellum and medulla were followed just beyond the third lamina. The dura was opened widely throughout the extent of the bone defect and dissection of the fibrous adhesions was carried anteriorly. The patient expired at the close of the operation. The operative findings were verified by post-mortem examination and all the characteristic features of the malformation were observed.

CASE 4.—P. R. W., a female infant, 11 weeks old, showed a spina bifida at the level of the fourth lumbar vertebra. There was a marked impairment in the use of the lower extremities and sphincter control was lost. There was an obvious hydrocephalus at this time, the head measuring 43 cm. at its greatest circumference.

During the last several weeks, the mother stated that the head had been growing extremely rapidly. On May 25, 1936, the day following examination, a suboccipital exposure was made. Marked hydrocephalus was shown by preliminary ventricular puncture. Through a midline incision, the occipital bone was rongeured away as far laterally as possible and the posterior margin of the foramen magnum and the arches of the first three cervical vertebrae were removed. The dura was opened widely throughout the extent of the bone defect and marked compression of the malformation was observed. Flaglike prolongations of the cerebellum were followed to the level of the second cervical vertebra, and beneath these and extending to the upper border of the fourth lamina small projections of the medulla were seen. Adhesions were quite marked around the region of the foramen magnum and just below it, but they did not extend far over the surface of the cerebellum. The malformation and the lower parts of the cerebellum were freed and the wound was closed. The patient was discharged on the eighth postoperative day and at this time the head measured the same as on admission. The patient's general condition improved following this procedure and the growth of the head was markedly diminished. On July 13, 1936, the patient was admitted to the hospital for repair of the spina bifida defect and at this time the head measured 43.5 cm. The sac was dissected free and opened. It was found to be multiloculated and several nerve roots were found adherent to it. The sac was closed and the fascia dissected free from the adjacent muscles was imbricated over it. Following operation the fontanelles again became tense and by the time of discharge, the eighteenth postoperative day, the circumference had increased to 47 cm. Measurements following discharge were as follows: Sept. 1, 1936, 50.8 cm.; Nov. 13, 1936, 53.7 cm. Since that time the head has shown no growth whatever, the circumference on May 4, 1937, remaining at 53.7 cm.

CASE 5.—J. M. H., a male infant, seen at the age of three months with a spina bifida in the lumbar region. There was a bilateral clubfoot and marked weakness of both lower extremities. Sphincter control was lost. The fontanelles at this time were tense and the head was enlarged, measuring 46 cm. He was observed over a period of one week and operated upon on Sept. 7, 1936. The head then measured 47.5 cm. Marked hydrocephalus was shown by preliminary ventricular puncture. A suboccipital exploration was done through a midline incision with removal of the arches of the first and second vertebrae. The cisterna magna was partially obliterated. Small flaglike projections of the cerebellum and small protrusions of the medulla were seen extending to the lamina of the second cervical vertebra. These were obscured somewhat by the leptomeninges which were thickened and vascular. A few adhesions bound the malformation to the surrounding structures and these were separated close to the dura. The dura was left widely open and the wound closed. On the fifth postoperative day, the head circumference was 47.3 cm. and on Sept. 16, 1936, the day of discharge, 48 cm. The fontanelles were soft at that time and the general condition of the patient improved. Subsequent measurements obtained were as follows: Nov. 7, 51 cm.; Jan. 28, 1937, 56.2 cm.; Feb. 13, 56.8 cm.; March 1, 57 cm.; March 13, 57 cm. At this time a fluid leak developed in the sac and following this the tension immediately increased and growth again became rapid. On May 12 the circumference measured 61 cm.

CASE 6.—R. M. B., a male infant, seen on March 6, 1937, immediately after birth with a spina bifida defect in the upper lumbar region. A segment of cord about 1 cm. long was exposed with no membrane over it. The lower extremities showed no movement and there was an apparent paralysis of the sphincters. Immediate operation was necessary because of the exposed cord and a repair of the defect was done

within that day. Rather large flaps of fascia from the adjacent muscles were imbricated over the sac, but the skin defect was so extensive that it could not be entirely closed. Granulation tissue was allowed to form over the fascial repair and this was covered with split grafts. Five days after operation the fontanelles became tense and the head began to enlarge. Three days later the circumference had increased to 34 cm. Two weeks after operation this measurement was 36 cm. and on the thirtieth postoperative day the circumference was 37.5 cm. A suboccipital exploration was done on April 13, 1937. On this day the greatest circumference measured 38.5 cm. Through a midline incision, the usual suboccipital exposure was accomplished and the arches of the first three cervical vertebrae were removed. The dura was opened throughout the extent of the bone defect and, in order to elevate it, it was necessary to sever many dense adhesions which were attached to the underlying arachnoid. The cisterna magna was entirely obliterated. A rather marked compression ring was seen and from the lower portion of the cerebellum a rather extensive prolongation was followed to a point just below the level of the third lamina. Just beyond its borders projections of medulla could be seen. The leptomeninges over the surface of the malformation were thickened and vascular. The vessels were markedly injected and there was some free blood noted in the arachnoid. Adhesions were found binding the malformation to the surrounding structures. Rather dense adhesions were also found in the region of the foramen magnum between the dura and the lower portion of the cerebellum. These were severed. The dura was left open for decompression and the wound was closed. Following operation the patient's condition rapidly improved and the fontanelles became soft. At discharge on the thirteenth day following the second operation the head showed no increase in size, the greatest circumference measuring 38.5 cm. On May 14, 1937, the head measured 41 cm., and on May 30, 41.8 cm.

RESULTS OF OPERATION

Operation on the malformation was performed in all six cases reported here and the spina bifida repair with conservation of the sac in five. In three cases operation on the malformation was followed by satisfactory results. In one case a good result has followed for seven weeks, but sufficient time has not elapsed to evaluate the final outcome. There was one operative mortality in the group and this was following operation on the malformation. One death occurred one year later from epidemic meningitis. The growth of the head from the time these patients were first seen is best shown in the graphs (Figs. 2 and 3). After operation on the malformation, the fontanelles became soft and in no instance did rapid growth immediately ensue, the head showing no increase in size whatever for periods of one to two weeks. The growth then again continued at an increased rate but more closely approaching the normal curve than before operation. In four out of five cases in which the spina bifida defect was repaired first, increased tension of the fontanelles and rapid enlargement of the head followed immediately after operation. In one these changes were delayed twelve days. In Case 4 the growth of the head following the suboccipital operation was less than the normal rate for seven weeks. At the end of this time a repair of the spina bifida was done and this immediately precipitated increased tension of the fonta-

nelles and rapid growth of the head. This rapid growth then gradually decreased over a period of four months, and, for six months following until the time of the last visit, the size remained stationary.

Similar changes occurred in Case 5, in which the spina bifida was not repaired. In this case, after a slow leveling of the growth curve, a fluid

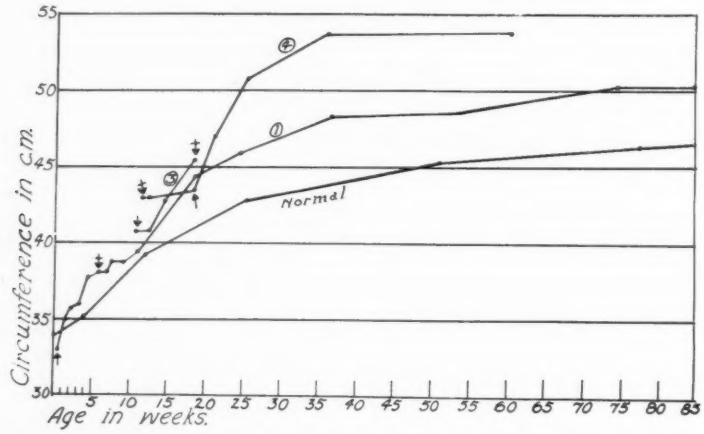

Fig. 2.—Growth curves of the head in Cases 1, 3, and 4. The uncrossed arrows represent the point at which spina bifida repair was done. The crossed arrows indicate operations on the malformation.

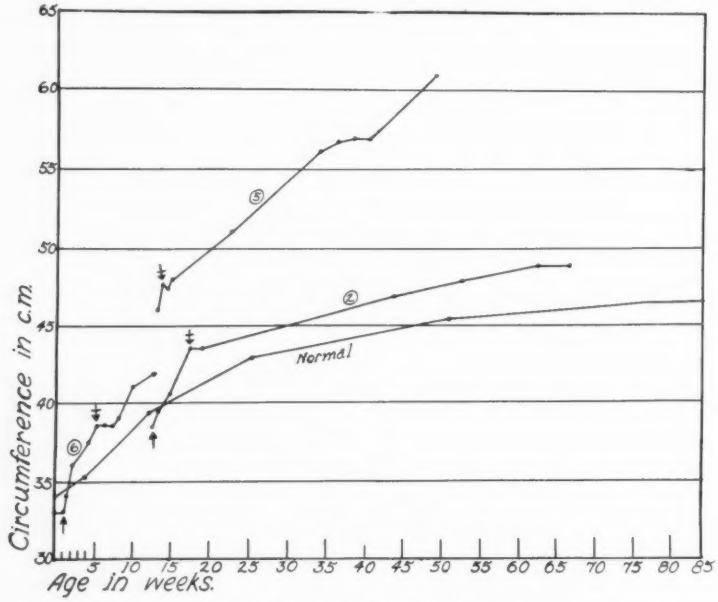

Fig. 3.—Growth curves of the head in Cases 2, 5, and 6. Uncrossed arrows represent spina bifida repair. Crossed arrows indicate operation on the malformation.

leak developed from the sac. There followed immediately tightness of the fontanelles and increased circumference of the head. With these changes there was no evidence of infection. The greatest occipitofrontal circumference, while not strictly accurate, has been chosen as being the most practical indication of the growth of the head.

COMMENT

In has been shown that withdrawal of large amounts of cerebrospinal fluid will stimulate increased production and the hydrocephalus might be thus accounted for. If this were the case, the fluid lost following the suboccipital operation should make the hydrocephalus worse. On the contrary, however, following this operation there is a retardation of the growth. Apparently an obstruction is brought about by the removal of the fluid from the spinal subarachnoid space which does not occur with loss of fluid from above. It may be that the opening of the dura provides an additional area for absorption, accounting for the short period immediately after operation during which no growth whatever occurs. This would not, however, explain improvement after a long period of time when the dura has again closed. Penfield and Grant both report death by allowing sudden change in pressure by loss of fluid from the sac. This suggests jamming of the malformation farther into the vertebral canal through too rapid removal of fluid below. Compression by this means may well occur with fluid loss from the sac following repair and account for an obstruction. Apparently even after operation on the malformation obstruction can occur by loss of fluid through repair of the sac or leakage from it as shown in Cases 4 and 5. The sac was conserved in all cases according to the method of Penfield and Cone, thus excluding loss of the sac as a factor. Even though the results of operation are not completely satisfactory from a surgical standpoint, the improvement thus far has been sufficient to justify continuing the procedure.

Encephalograms have not been attempted in these cases as yet as the risk of such a procedure has been considered too great.

SUMMARY

1. The Arnold-Chiari malformation was observed at operation in six consecutive cases of myelomeningocele.

2. Hydrocephalus was found to be associated in every case.

3. Operation upon the malformation was followed by variable improvement; in three cases the results have been considered satisfactory; in one sufficient time has not elapsed for proper evaluation of the result. There was one operative death and this following operation on the malformation.

4. The situation of the malformation and its anatomic relation to the cerebrospinal channels suggest that it is a major factor in the production of the hydrocephalus.

5. In three cases hydrocephalus preceded repair of the spina bifida.

6. In four cases increased tension of the fontanelles and abnormal enlargement of the head were precipitated or increased by the spina

bifida repair; in one case these changes were delayed twelve days; in Case 5 more rapid growth of the head immediately followed a fluid leak from the sac.

7. It is thought that withdrawal of the fluid from the sac by any means will precipitate or increase the hydrocephalus.

REFERENCES

1. Cutler, G. D.: End-Results in Sixty-Two Cases of Spina Bifida and Cephalocele, Arch. Neurol. & Psychiat. **12**: 149, 1924.
2. Craig, W. M.: Spina Bifida: Preoperative, Surgical and Postoperative Treatment, S. Clin. North America **9**: 219, 1929.
3. Penfield, Wilder, and Cone, William: Spina Bifida and Cranium Bifidum, J. A. M. A. **98**: 454, 1932.
4. Kolodny, Anatole: Results of Surgery in Spina Bifida, J. A. M. A. **101**: 1626, 1933.
5. Arnold, J.: Ziegler's Beitr. **16**: 105, 1894.
6. Russell, Dorothy S., and Donald, Charles: The Mechanism of Internal Hydrocephalus in Spina Bifida, Brain **58**: 203, 1935.
7. Graftdijk, C. J. van Houweninge: Thesis entitled, "Over Hydrocephalus," quoted from Russell and Donald.

DEXTROSE UTILIZATION IN SURGICAL PATIENTS*

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SINCE there is considerable diversity of opinion on this subject among experienced clinicians, an evaluation of the respective advantages of 5 and 10 per cent dextrose solution for parenteral administration to the sick surgical patient was thought to be of value. The use of 5 per cent dextrose in distilled water has long been a routine on the surgical service at the University Hospital for the patient who, because of his disease or operation, cannot take sufficient fluids orally to care for his needs.[1] Abnormal losses through vomitus, biliary and enterostomy drainage, and other sources of salt loss are covered with parenteral physiologic saline or Ringer's solution.[2] In this study particular attention was given to the utilization of dextrose when administered in a 5 or 10 per cent solution.

Twenty-six male patients who had undergone surgical procedures and one patient undergoing preparation for surgery were followed over a period of from two to ten days, during which time the amount and rate of administration of intravenous fluids were carefully checked. There were 8 cases of gastric carcinoma; 5 of duodenal ulcer; 2 cases each of chronic ulcerative colitis and carcinoma of the rectum. There was 1 case each of carcinoma of the ascending colon, carcinoma of the splenic flexure, perforated gastric ulcer, toxic goiter, chronic cholecystitis, biliary cirrhosis, inguinal hernia, perforated appendicitis, biliary duct carcinoma, and incisional hernia. Eighteen patients received only 5 per cent dextrose; 4 received 10 per cent alone; and 5 patients received both solutions.

METHOD

Wherever possible, a timed intravenous pump was used to obtain accurate control of the amount and velocity of injection of the dextrose solution. Woodyatt[3] stressed the importance of this control and developed a motor-driven intravenous pump for this purpose. The device used in this study consisted of a 3 c.c. Luer-Lok syringe on a revolving adaptable drum which was driven by an electric motor. The complete apparatus produced a continuous flow of fluid into the vein of the patient. The adaptable drum and a gear reducer permitted wide ranges in the velocity of the intravenous administration. Occasionally several patients were followed at the same time, and this necessitated the use

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of the routinely utilized intravenous drip apparatus. The latter was subject to variations in the speed of its delivery because of differences in the caliber of the needle and the vein used, in the height of the Kelly bottle above the patient, in the position of the patient's arms, in coiling or twisting of the delivery tube, and other factors.

The daily routine consisted of weighing the patient each morning on a Bradford frame which was placed on a Howe scale accurate to 0.01 kg. In the earlier cases only one reading was taken at the onset of each individual study, but later the patient was weighed at the same time each day. All fluid additions to the Kelly bottle were made by the observer at intervals of thirty to sixty minutes, and the reading on the burette was checked frequently to promote a uniform velocity of flow. Urine specimens were obtained at hourly intervals whenever possible, and often at shorter intervals. Each urine specimen was immediately analyzed for its dextrose content, using Benedict's qualitative test first, and was followed by a quantitative determination whenever the first test was positive. Specimens obtained during the night were placed in the refrigerator and analyzed the following morning. Total fluid intake was noted daily, along with the total output of all fluids: urine, vomitus, sputum, enterostomy, and fistula drainage. The patient's temperature was charted every four hours and any unusual reactions or incidents during the period of observation were carefully noted. Only two of the patients had chills and fever that could be related to the intravenous administrations, and in both cases the reactions were brief and apparently harmless.

Tables I and II contain the essential data obtained from the study. The comment of the following paragraphs is limited to points of particular interest, comparing our results with the observations of others interested in this particular phase of the pre- and postoperative care of surgical patients. Although the frequently used term "utilization of dextrose" is not absolutely correct, since there is no proof that all of the dextrose retained by the patient is utilized, it is preferred to the more comprehensive term "retention." Frequent reference to glycosuria tends to place undue emphasis on this phase of the study unless one understands that this term is used as our index of dextrose utilization.

TIME RELATION

In comparing degrees of glycosuria of individual patients, it was necessary to compare results on corresponding postoperative days because of variation in the ability to utilize dextrose as the convalescence lengthened. There was always a maximum glycosuria on the day of the operation, a marked decrease occurred on the first postoperative day, and, with rare exceptions, there was another abrupt decrease in glycosuria the second postoperative day. From then on a few cases showed

a gradual decrease in glycosuria, but a more frequent finding was a moderate rise in glycosuria throughout the third and fourth (rarely the fifth) postoperative days, after which it decreased again.

Age played an unimportant part in regard to the degree of glycosuria.

DEGREE OF NUTRITION

Degree of nutrition proved to be an important factor affecting the ability to utilize dextrose in both groups. The cases were classified as having good, fair, or poor nutrition according to their physical condition and degree of nourishment at the time of their operation. In the group given 5 per cent dextrose (Table I), the utilization of sugar was equally good in patients of good or fair nutrition. Two patients showing poor nutrition spilled excessive amounts of dextrose in the urine and this group as a whole exhibited higher degrees of glycosuria than those of good or fair condition. Colwell[4] has noted in his experimental work that the ability of the normal mammalian organism to utilize dextrose is diminished by starvation and enhanced by the administration of sugar.

PREOPERATIVE DEXTROSE THERAPY

Five of the patients had been given intravenous dextrose for from two to nineteen days prior to the operation and three were given a high carbohydrate diet for from five to seven days preoperatively, in an attempt to "fortify" the liver and to increase its ability to store glycogen. The patients given adequate and prolonged carbohydrate therapy preoperatively showed more efficient utilization of the dextrose given them after the operation than did the average patient. This suggests the importance of this therapeutic measure, particularly in patients who are in poor condition upon admission to the hospital. Colwell[4] and La Roeque[5] demonstrated this action of dextrose and emphasized its beneficial effect upon the liver. Althausen's[6] excellent work on dextrose therapy in liver disease produced unquestionable proof that the damaged or diseased liver can be forced to store glycogen with the use of proper dextrose therapy. He biopsied the livers of fourteen patients with marked subacute or chronic involvement of this organ. The livers of patients who received no dextrose preoperatively were almost devoid of glycogen; whereas, the hepatic cells in sections from patients who had received large amounts of dextrose prior to operation were literally filled with glycogen. Graham[7] has reported a striking decrease in his operative mortality in cases of biliary tract disease since adopting the policy of preparing his patients preoperatively with dextrose. Adequate preoperative dextrose therapy has been adopted as a routine procedure on the surgical service of the University Hospital for biliary tract and large bowel surgery in particular, and has had the predicted and desired effect of minimizing postoperative complications and of aiding in the reduction of postoperative mortality.

TABLE I

DATA FROM PATIENTS RECEIVING 5 PER CENT DEXTROSE

CASE	OPERATION AND DIAGNOSIS	STATE OF NUTRITION	DAY POST-OPERATIVELY	RATE IN C.C./HR.	TOTAL DEXTROSE GIVEN (C.C.)	TOTAL GM. DEXTROSE	GM. DEXTROSE PER KG./HR.	TOTAL FLUID INTAKE (C.C.)	TOTAL URINE OUTPUT (C.C.)*	GM. DEXTROSE IN URINE	PER CENT DEXTROSE RETAINED
M. Le.	Gastroenterostomy for carcinoma of stomach	Poor	Op.†	365.7	2,560	128.00	0.31	3,560	978	6.52	94.9
			1	341.8	2,450	122.50	0.29	3,450	1,062	0.70	99.4
			2	360.1	3,000	150.00	0.31	3,500	811+	0.62	99.6
R. B.	Gastric resection for duodenal ulcer	Good	2	293.3	3,030	151.50	0.22	3,530	3,363	0.30	99.8
			3	360.1	3,000	150.00	0.27	3,500	2,247	1.09	99.3
			4	385.8	3,505	175.25	0.29	4,485	2,781	0.67	99.5
			5	310.5	3,000	150.00	0.23	3,910	1,957	1.05	99.3
M. Ly.	Devine exclusion for duodenal ulcer	Fair	2	423.0	3,005	150.25	0.31	3,505	2,230	2.17	98.5
			3	360.1	3,000	150.00	0.26	4,000	2,875	3.80	97.4
			4	403.2	2,065	103.25	0.29	3,955	1,080+	0.62	99.4
			5	411.6	3,000	150.00	0.30	3,800	1,259+	0.50	99.6
W. H.	Gastric resection, cholecystostomy, gastric carcinoma and cholelithiasis	Poor	1	316.1	2,845	142.25	0.28	3,545	1,085	2.02	98.6
			2	342.6	3,110	155.50	0.31	3,610	2,922	1.09	99.3
			3	321.6	2,650	132.50	0.30	3,650	1,268	0.97	99.2
			4	344.0	2,580	129.00	0.33	4,080	2,243	1.09	99.1
			5	359.4	2,500	125.00	0.35	3,300	1,867	2.34	98.1
S. A.	Devine exclusion for duodenal ulcer	Fair	5	309.0	2,500	125.00	0.27	3,760	697	0	100.0
			6	435.0	2,610	130.50	0.39	3,670	2,238	4.25	97.1
			7	311.4	2,180	109.00	0.27	2,930	1,853	1.01	99.1
			8	313.0	1,565	78.25	0.28	1,925	1,649	1.15	98.5
C. S.	Repair of perforated duodenal ulcer	Poor	5	313.9	2,615	135.75	0.42	3,115	1,848	1.35	99.0
			6	325.6	2,605	130.25	0.43	3,605	2,099	1.77	98.6
			7	311.4	2,180	109.00	0.42	3,180	817	0.50	99.5
G. N.	Sidetracking anastomosis for carcinoma of descending colon	Poor	3	333.3	2,000	100.00	0.35	3,000	1,522	0	100.0
			4	493.7	1,975	98.75	0.51	3,125	1,538	0	100.0
			5	497.5	1,990	99.50	0.52	2,990	970	0	100.0
S. S.	Gastric resection for carcinoma of stomach	Poor	4	505.0	2,525	126.25	0.47	3,385	2,210	2.74	97.7
			5	518.3	3,110	155.50	0.49	4,830	3,753	1.98	98.7
			6	320.7	2,030	101.50	0.30	5,230	2,551	0	100.0

TABLE I—CONT'D

J. Ma.	Appendectomy for ruptured appendix	Good	6	503.3	3,020	151.00	0.30	4,020	1,493	0	100.0
			7	480.7	3,125	156.25	0.29	4,425	3,183	0	100.0
C. J.	Herniorrhaphy for inguinal hernia	Good	Op.	318.3	1,910	95.50	0.26	2,310	826	2.14	97.7
			1	306.2	1,225	61.25	0.25	3,850	1,579	0	100.0
K. R.	Ileosigmoidostomy for chronic ulcerative colitis	Good	3	239.0	2,450	122.50	0.27	3,275	937	0.19	99.8
			4	333.5	2,335	116.75	0.38	3,665	1,711	0.47	99.6
			5	300.0	1,500	75.00	0.35	3,[illegible]0	1,312	0	100.0
J. G.	Biopsy liver for biliary cirrhosis	Fair	Op.	375.0	3,000	150.00	0.33	3,[illegible]0	1,413	0	100.0
			1	413.5	2,895	144.75	0.36	4,095	3,177	0	100.0
E. C.	Gastroenterostomy for carcinoma of stomach	Poor	Op.	270.9	3,590	179.50	0.22	4,590	787	26.36	85.3
			1	303.5	3,135	156.75	0.26	4,135	650	12.91	91.7
			2	335.0	2,010	100.50	0.27	4,010	976	4.59	95.4
			3	326.3	2,855	165.25	0.26	2,855	506	0.28	99.8
J. R.	Cholecystectomy for cholecystitis	Good	Op.	277.7	2,500	125.00	0.19	3,500	880	10.80	91.3
			1	290.4	3,000	150.00	0.20	3,500	2,875	6.52	95.6
			2	349.3	2,445	122.25	0.24	3,000	1,463	1.47	98.7
			3	473.4	3,000	150.00	0.33	3,500	2,817	6.89	95.4
			4	369.0	2,000	100.00	0.27	2,650	1,498	2.85	97.1
			5	402.0	2,010	100.50	0.30	3,310	602+	2.14	96.8
A. W.	Gastric resection for duodenal ulcer	Good	1	505.0	3,535	176.75	0.36	3,835	2,232	11.61	93.4
			2	505.0	3,535	176.75	0.36	3,835	2,692	5.45	96.9
			3	501.2	3,500	175.00	0.37	3,950	2,877	7.05	95.9
			4	496.4	3,500	175.00	0.37	3,950	1,720	8.38	95.2
			5	500.0	3,500	175.00	0.37	3,950	3,460	10.21	94.1
J. J.	Gastroenterostomy for carcinoma of stomach	Poor	1	320.4	3,500	175.00	0.25	3,500	1,152	1.77	98.9
			8	331.8	2,025	101.25	0.27	2,945	1,365	1.07	98.9
			9	390.0	2,340	117.00	0.32	3,400	2,141	1.89	98.4
			10	379.8	1,045	52.25	0.31	2,785	1,435	0.98	98.1
R. C.	Gastrostomy for carcinoma esophagus	Poor	4	380.9	4,000	200.00	0.39	4,180	424+	3.77	98.1
			6	411.5	3,840	192.00	0.42	3,840	2,652	1.59	99.1
C. E.	Thyroidectomy for toxic goiter	Good	Op.	227.7	3,500	175.00	0.16	4,400	1,249	0.59+	99.6
			1	371.6	2,230	111.50	0.27	6,400	2,977	1.62	98.5
										Average	98.01

*+ Indicates specimens lost or discarded; or incontinence of patient.
†*Op.* indicates day of operation.

TABLE II

DATA FROM PATIENTS RECEIVING BOTH 5 AND 10 PER CENT DEXTROSE, AND ONLY 10 PER CENT DEXTROSE*

CASE	OPERATION AND DIAGNOSIS	STATE OF NUTRITION	PER CENT DEXTROSE	DAY POST-OPERATIVELY	RATE IN C.C./HR.	TOTAL DEXTROSE GIVEN (C.C.)	TOTAL GM. DEXTROSE	GM. DEXTROSE PER KG./HR.	TOTAL FLUID INTAKE (C.C.)	TOTAL URINE OUTPUT (C.C.)	GM. DEXTROSE IN URINE	PER CENT DEXTROSE RETAINED
				5 and 10 Per Cent Dextrose								
H. W.	Gastric resection for carcinoma of stomach	Good	10	1	411.7	3,500	350.00	0.71	4,000	953	13.90	96.0
				2	375.1	3,500	350.00	0.64	4,000	2,943	16.83	95.1
				3	420.0	3,500	350.00	0.68	4,000	2,570	45.69	86.9
				4	375.1	3,500	350.00	0.67	4,000	3,483	54.64	84.3
			5	5	501.4	3,510	175.50	0.45	3,900	2,860	7.68	95.6
V. M.	Resection cecum for carcinoma	Good	5	3	320.4	3,150	157.50	0.20	3,910	1,312	0	100.0
				4	323.2	3,070	153.50	0.20	4,350	2,729	0	100.0
				5	466.6	2,100	105.00	0.30	4,570	2,168	0	100.0
	Closure of ileostomy	Good	10	1	505.8	3,500	350.00	0.69	3,500	1,072	9.52	97.2
				2	498.0	3,530	353.00	0.67	3,530	3,393	37.94	89.2
				3	505.8	3,500	350.00	0.70	3,500	3,422	41.68	88.1
				4	508.8	3,520	352.00	0.71	3,520	2,720	41.10	88.3
				5	508.2	3,500	350.00	0.70	3,500	2,745	29.92	91.4
M. J.	Resection of sigmoid colon; sigmoid polypus and chronic ulcerative colitis	Good	5	1	316.8	3,010	150.50	0.24	4,010	1,774	2.62	98.2
				2	289.2	3,135	156.75	0.22	4,135	912	0.38	99.7
			10	3	295.8	3,090	309.00	0.45	4,090	842	10.65	96.5
				6	367.2	3,520	376.00	0.56	4,000	1,252	29.02	92.3
				7	283.8	3,500	350.00	0.43	3,500	996	15.05	95.7
				8	313.2	3,500	350.00	0.47	3,500	1,366	13.69	96.1
				9	315.6	3,565	356.50	0.48	3,715	1,593	6.65	98.1
				10	275.0	2,200	220.00	0.43	3,925	783	1.02	99.5

TABLE II—CONT'D

J. H.	Abdominal perineal resection for carcinoma of rectum	Good	5	1	297.6	3,500	175.00	0.26	3,500	633	1.42	99.2
				2	318.2	3,500	175.00	0.28	3,500	1,710	3.10	98.2
			10	3	314.1	2,670	267.00	0.56	2,670	1,170	22.63	91.5
				6	406.6	3,050	305.00	0.73	4,725	1,378	23.36	92.3
T. M.	Cholecysto-gastrostomy; common duct carcinoma			Preop.†								
			10	18	411.6	2,025	202.50	0.84	3,725	2,708	0.64	99.6
				17	329.1	1,975	197.50	0.67	4,275	1,617	2.03	99.0
		Poor	5	16	500.0	2,000	100.00	0.51	4,600	2,051	0.81	99.2
				15	253.2	1,690	169.00	0.51	3,340	1,547	3.05	98.1
			10	14	371.2	1,980	198.00	0.76	3,780	1,295	1.34	99.2
			5	Op.‡	261.7	4,450	222.50	0.54	6,875	350	0.33	99.8
						10 Per Cent Dextrose						
I. D.	Gastric resection duodenal ulcer	Good		1	452.2	3,015	301.50	0.46	3,015	1,267	26.37	91.2
C. D.	Repair incisional hernia; resection of ileum and fibroma durum			1	496.2	3,020	302.00	0.72	3,020	2,099	8.94	97.0
				2	504.1	3,025	302.50	0.74	3,025	2,424	20.68	93.1
		Good		3	495.6	3,000	300.00	0.74	3,300	2,797	38.50	87.1
				4	504.1	3,025	302.50	0.76	3,355	2,271	23.34	92.2
				5	513.6	3,040	304.00	0.80	3,880	3,543	29.11	90.4
G. W.	Sigmoid colostomy for carcinoma of rectum			1	317.7	3,495	349.50	0.48	3,495	2,460	5.29	98.4
				2	318.2	3,500	350.00	0.49	3,500	2,106	0.34	99.9
		Good		3	293.5	3,375	337.50	0.46	3,575	1,980	1.25	99.6
				4	424.2	3,500	350.00	0.66	3,950	3,161	1.19	99.6
				5	434.5	3,585	358.50	0.69	4,035	2,317	3.29	99.1
A. N.	Gastric resection for carcinoma of stomach			1	309.1	3,400	340.00	0.61	3,500	1,086	9.35	97.2
				2	302.1	2,945	294.50	0.59	3,345	1,996	7.91	97.3
				3	326.6	3,185	318.50	0.64	3,285	2,956	4.35	98.6

*Average of all cases given 5 per cent—98.5.
Average (last 4 patients)—95.7.
Average of all cases on 10 per cent—94.85
†14 to 18 days prior to operation.
‡Day of operation.

There was no marked variation in the utilization of dextrose according to the type of operation or anesthesia, except that the simpler procedures were accompanied by less postoperative glycosuria as a rule than the more serious operations, and increased glycosuria usually occurred in patients having a long inhalation anesthesia.

FEVER

In the group receiving 5 per cent dextrose, three patients whose temperature ranged from 101 to 102° for one to three days showed a glycosuria above the average of the group. It was noted that all three exhibited poor nutrition. Two patients in good nutrition spilled no dextrose on the first postoperative day when their temperature was 101 to 102°, and a third patient in good nutrition spilled no dextrose on his third and fourth postoperative days when his temperative was 103°.

The two patients in the group given 10 per cent dextrose who had elevations of temperature to 101 to 103° spilled from 50 to 200 per cent more dextrose than those who were afebrile and both were noted to be in good condition preoperatively. This finding of a lessened degree of dextrose utilization in patients with prolonged febrile reactions is contrary to the results of Hendon,[8] who found that patients suffering with severe toxemia and fever consumed at least twice as much glucose in twenty-four hours as patients without these complications. Allen[9] also reported increased retention of sugar in the presence of fever.

DISEASE

It was difficult to evaluate variations in degrees of glycosuria in different types of disease. Here again the patients in the best physical condition utilized the highest percentage of dextrose, and those in poor condition the least. The cases of far-advanced carcinoma of the stomach with regional and distant metastases showed a uniformly high glycosuria, and with one exception the cases of cholecystitis or those showing liver damage failed to utilize dextrose as well as the average of the group. The cases of duodenal ulcer showed better utilization than the previously mentioned group, and the toxic goiter and the uncomplicated hernia showed complete utilization of dextrose in the two-day period. Cases of carcinoma of the colon could assimilate large amounts of dextrose without measurable glycosuria. Postoperative pneumonia appeared to decrease the utilization of dextrose.

RATE OF ADMINISTRATION

According to Woodyatt's early studies,[10] when 10 to 50 per cent dextrose solution is introduced directly into the vein of a normal healthy adult, the normal tolerance limit, expressed as velocity, is established at close to 0.85 gm. of dextrose per kilogram of body weight per hour.

This figure was the result of very carefully controlled studies over periods of from six to twelve hours on rabbits, dogs, and human beings. Thus, a healthy 60 kg. man could be expected to utilize 51 gm. of dextrose in an hour (500 c.c. of 10 per cent, or 1,000 c.c. of 5 per cent, dextrose solution hourly). When dextrose was given by vein faster than 0.9 gm. per kg. of body weight per hour, glycosuria appeared; then usually a little later, diuresis.

Wilder and Sansum[11] found variations of this tolerance figure in various diseases. A case of chronic pancreatitis showed a dextrose tolerance below 0.7 gm. per kg. body weight per hour, and two cases of mild diabetes mellitus showed a dextrose tolerance below 0.4 gm. and 0.5 gm. per kg. body weight per hour, respectively. Five cases of exophthalmic goiter had a decreased glucose tolerance, the two most severe cases spilling sugar at a rate of 0.5 gm. per kg. per hour. A case of myxedema showed a normal glucose tolerance, as did a case of alcoholic cirrhosis. Erlanger and Woodyatt[12] found the most appropriate injection rate for patients in shock to be 0.3 to 0.6 gm. of dextrose per kg. per hour. Matas,[13] in discussing the use of the continuous intravenous drip for patients in the collapsed state, advised the administration of 5 per cent dextrose at a rate of 200 c.c. per hour. He found no glycosuria at this rate when the administration was continuous for five or more days.

Fantus[14] found that Woodyatt's figure of 0.85 gm. per kg. body weight per hour was an excessive rate of dextrose administration for postoperative patients. Whereas this figure permits the administration of 51 gm. of dextrose per hour to the 60 kg. person, or 1,224 gm. in twenty-four hours, Fantus found that about one-third of all patients given between 100 and 149 gm. of dextrose in twenty-four hours eliminated sugar in the urine. The group given between 150 and 199 gm. in twenty-four hours showed glycosuria in more than one-third of his cases and in the group given more than 200 gm., 50 per cent of all the patients passed sugar in the urine. He did not mention the rate of administration of the dextrose solution. In an earlier paper, Fantus[15] stated that a 10 per cent solution can be administered intravenously at the rate of 500 c.c. an hour before the sugar tolerance of the average individual is overcome as evidenced by glycosuria.

Orr[16] has cautioned against overburdening a weakened circulatory system by giving large quantities of intravenous fluids too rapidly. He also reported two cases of peritonitis following ruptured appendices who developed signs of acute nephritis, as evidenced by edema and hematuria. One was given 5 per cent dextrose continuously for ten days, the other 10 per cent dextrose in physiologic solution of sodium chloride for several days. The urinary findings disappeared when the infusions were stopped, this convincing him that the intravenous fluids had produced kidney irritation. Orr[17] has advised the administration of 10 per cent

dextrose at a rate of 500 c.c. in one to one and one-half hours, and a continuous intravenous drip at 30 to 60 drops per minute.

De Takats[18] has recommended the administration of 100 gm. of dextrose daily to postoperative patients to combat the acidosis which is the consequence of starvation. Horsley[19] advised 5 per cent dextrose in Ringer's solution for several days at rates of 150 to 200 c.c. an hour continuously. Glycosuria was a rare finding at this rate. He felt that 10 per cent dextrose was too hypertonic for general use, except in the presence of kidney disease. Hendon[8] has found 200 c.c. an hour an optimum rate for intravenous dextrose administration and gives four to five liters in twenty-four hours, using 10 per cent dextrose in physiologic saline solution most frequently. The daily total of fluids given is governed by the appearance of sugar in the urine. Hendon does not believe that glycosuria is alarming, but considers it evidence that the physiologic demands of the individual have been fulfilled.

UTILIZATION AT DIFFERENT RATES

In our earlier experiments various rates of intravenous administration were used on the same patient, and in the later studies a constant rate was maintained as well as possible with the motor driven intravenous pump. Although poor nutrition, fever, severity of the disease, duration of and type of anesthesia, and preoperative preparation produced variations in the amount of dextrose retained in similar types of cases, the rate at which the dextrose solution was given proved to be the most important factor affecting dextrose utilization. In the following analysis the other factors have been dismissed, and consideration is given to the rate at which the dextrose solution was administered on corresponding postoperative days.

Five per cent dextrose in distilled water was given to the 19 patients in the first group. The rate of administration was 239.02 to 518.3 c.c. per hour, and, since almost all of the lower rates were approximately 300 c.c. per hour, a range of 300 to 500 c.c. an hour can be established for all practical purposes. The duration of administration varied from 3 to 13 hours, averaging about 7 hours, and the total amounts given were from 2,000 to 3,500 c.c., averaging almost 3,000 c.c. daily. The data showed that 15 of the 19 patients, or 79 per cent, exhibited a glycosuria with several or with all individual administrations of 5 per cent dextrose solution.

The amounts of dextrose spilled in the urine, even at the higher rates, were, with rare exceptions, insignificant. On an average, only 1.5 per cent of the dextrose administered appeared in the urine. Thus, only 2.25 gm. of a daily average of about 150 gm. of dextrose was not utilized. Only 14 of 64 twenty-four-hour urine specimens contained more than 3 gm. of dextrose and the remaining 50 averaged far below this amount. These figures are based on the administration of 5 per cent

dextrose at rates of 0.2 to 0.5 gm. per kg. of body weight per hour (300 to 500 c.c. per hour), an average of 0.35 gm. per kg. of body weight hourly. This value is far below Woodyatt's[10] stated 0.85 gm. per kg. of body weight hourly, and demonstrates that a lower rate is needed in postoperative surgical cases if complete utilization of the administered dextrose is desired. All patients were carefully checked for evidence of dehydration, water retention, unusual diuresis, any other abnormal effects, but none of these features were observed at these rates.

At times the patients voided more often than was their custom, and complained of this frequency, but the urinary outputs were not grossly abnormal. Occasionally a patient complained of a feeling of generalized fullness with intravenous rates approaching 500 c.c. per hour, declaring that their stomach, intestines, bladder, and even their extremities felt tense. In none did 5 per cent dextrose produce actual abdominal distention, nor were there other signs of inhibition of intestinal tone.[20] Microscopic studies of urine sediments were done from time to time to detect any kidney damage at the higher rates, but none showed microscopic hematuria or casts.[16]

A more accurate evaluation of the urinary output is found when the total daily intake is considered. Many of the patients received some physiologic solution of sodium chloride to maintain their chlorides, particularly when they were losing salt by vomitus, enterostomy drainage, and fistulas. With rare exceptions, patients receiving 5 per cent dextrose at the faster rates excreted the largest amounts of urine in twenty-four hours. Some of the higher urinary outputs suggest that dehydration will be produced if a high rate of administration is maintained over prolonged periods, but none was noted in the usual three- to five-day periods during which these patients were observed. The average sick patient on the surgical wards of the University Hospital infrequently requires intravenous fluids beyond the fifth postoperative day, although a few cases were observed for from eight to ten days. Previous studies[1] have shown that a daily urine output of about 1,500 c.c. is desirable for the seriously ill, usually septic, surgical patient.

Turning to the group of patients given 10 per cent dextrose intravenously, it was found that none of them utilized all of the administered dextrose. Thus, every daily administration of 10 per cent dextrose intravenously was attended by some glycosuria in the eight patients studied for three or more days. The rate of administration varied from 283.8 to 513.6 c.c. per hour, an approximate range of 300 to 500 c.c. an hour. The duration of the daily administration varied from 5 to 12 hours, and the total amount of 10 per cent solution varied from 2,000 to 3,500 c.c., usually the latter, each day. While glycosuria occurred daily in this group of cases, it is important to note that the actual amount of dextrose in the urine was usually quite small, the average being only

5.15 per cent of the total dextrose given. The administration of 10 per cent dextrose solution at rates of 300 to 500 c.c. per hour is equivalent to 0.4 to 0.8, or an average of 0.6 gm. of dextrose per kg. of body weight per hour. This is less than Woodyatt's figure for healthy adults, and approximates more nearly the figures of Wilder and Sansum for various diseases.[11]

Although the daily urinary output of the patients receiving 10 per cent dextrose was as a rule slightly greater than that of the patients given 5 per cent dextrose, no definite dehydration, edema, or grossly abnormal diuresis was observed in the second group as shown in Tables I and II. Two patients in this group of nine occasionally complained of a sensation of generalized fullness at rates of 500 c.c. per hour, but again there was no definite abdominal distention. Microscopic studies of urine sediments revealed no kidney damage.

Comparing patients who received both 5 and 10 per cent dextrose solutions, the rate of administration is found to be a more important factor than the concentration of dextrose when their comparative influence on urinary output is evaluated.

Allen[9] declared that dextrose is mostly consumed in the tissues and found that, even with rapid injection, generally less than half appears in the urine. He observed that the slower the injection, the greater the utilization of dextrose, and consequently the less diuresis that may be expected. This coincides with the findings of this study.

In most of the patients the specific gravity of each urine specimen was recorded and it was found that with a four-plus glycosuria, which was a common observation, the specific gravity still fell within normal limits. It is common knowledge that glycosuria has no harmful effect upon renal function in nondiabetic patients.

Comparing the value of the two solutions in sick surgical patients, this study favors the use of 10 per cent dextrose in distilled water whenever a high caloric or a high carbohydrate intake is desired. The patients given 5 per cent dextrose spilled 1.5 per cent of the administered dextrose, or approximately 2.25 gm. of the average daily 150 gm. intake, utilizing 147.75 gm.; and those given 10 per cent dextrose spilled 5.15 per cent, or 15.5 gm. of the daily 300 gm. intake, utilizing 284.5 gm. Since the majority of cases on 10 per cent dextrose administration had a daily intake of 3,500 c.c., they actually utilized 332 gm., representing an intake of 1,328 calories. This figure is in the lower range of the caloric requirement of the resting surgical patient without fever or severe infection, various authors quoting the daily requirement of a 60 kg. resting patient as 1,200 to 2,000 calories. It is obvious that the 689 calories provided daily to the patient receiving 3,500 c.c. of 5 per cent dextrose is far below the basal energy needs.

PARADOXICAL LAW OF DEXTROSE

In the above comparison of the utilization of 5 and 10 per cent dextrose, we have demonstrated a phenomenon which Allen[9] termed the "dextrose paradox" or the "paradoxical law of dextrose." This term is used to designate "that remarkable power of every nondiabetic organism to utilize dextrose in absolutely unlimited quantity." He further stated: "Of genuine limitations of the power of the normal organism to metabolize dextrose administered by any or all of the possible channels, absolutely none exist. For the amount of the sugar utilized is governed not by any restriction of power on the part of the organism; it is governed only by the dose. Give the sugar by any route; increase the quantity at pleasure; it is possible by sufficient dosage to kill the animal, but it is not possible to cause more than a fraction of the whole to be excreted in the urine." Lusk's[21] experimental work has shown that metabolism is increased by an increase of food substances in the blood, following the ingestion of either sugar or fat, demonstrating a normal increased combustion of sugar due directly to an increased supply of sugar. The increased dextrose intake provides an increased storage of glycogen in the liver and muscles. The ability of the patients in this study to retain 98 per cent of the 5 per cent dextrose and 95 per cent of 10 per cent dextrose solution ably demonstrates Allen's "dextrose paradox."

COMMENT

The routine use of 5 per cent dextrose in distilled water for patients who require water and some carbohydrate parenterally, either in preparation for or following an operation, is recommended for several reasons. It is isotonic with blood. Its dextrose content is sufficient to prevent ketosis and to provide ideal fuel for energy. It protects the liver and avoids the edema which may result from the promiscuous use of physiologic solution of sodium chloride. No serious complications, such as dehydration, diuresis, unusual loss or retention of fluids, which might be ascribed to the dextrose solution have been noted when three liters are administered daily at rates of 300 to 500 c.c. per hour. This is an inadequate daily caloric intake, but this is not an important objection in patients with fair general nutrition, or in those who will be taking food by mouth in a few days. It has been shown that about 98 per cent of the dextrose is utilized when administered at the rate of 300 to 500 c.c. per hour, averaging 0.35 gm. of dextrose per kg. of body weight per hour.

Ten per cent dextrose in distilled water is hypertonic with blood, is mildly diuretic, and can be given at the same rates of administration as 5 per cent dextrose without harmful effects, supplying the patient with 93 per cent more carbohydrate than an equal volume of 5 per cent dextrose solution. In this study 95 per cent of the administered dextrose

(10 per cent solution) was utilized, making this solution our choice in the presence of liver damage, thyroid crisis, inanition, and cachexia. Although no measurable damage was noted at a rate of 500 c.c. per hour, administration of the 10 per cent solution at 200 to 300 c.c. hourly is preferred to increase its utilization.

REFERENCES

1. Maddock, W. G., and Coller, F. A.: Water Balance in Surgery, J. A. M. A. **108**: 1, 1937.
2. Coller, F. A., Dick, V. S., and Maddock, W. G.: The Maintenance of Normal Water Exchange with Intravenous Fluids, J. A. M. A. **107**: 1522, 1936.
3. Woodyatt, R. T.: The Method of Timed Intravenous Injections, J. Biol. Chem. **29**: 355, 1917.
4. Colwell, A. R.: The Use of Constant Glucose Injections for Study of Induced Variations in Carbohydrate Metabolism, Am. J. Physiol. **91**: 664, 1930.
5. La Rocque, C.: The Effects of General Anesthetics on the Liver, Canad. M. A. J. **12**: 566, 1922.
6. Althausen, T. L.: Dextrose Therapy in Diseases of the Liver, J. A. M. A. **100**: 1163, 1933.
7. Graham, E. A.: Lowering the Mortality After Operations on the Biliary Tract, Illinois M. J. **60**: 196, 1931.
8. Hendon, G. A.: Venoclysis, J. A. M. A. **95**: 1175, 1930.
9. Allen, F. M.: Studies Concerning Glycosuria and Diabetes, Cambridge, Mass., 1913, Harvard University Press, Chapter I.
10. Woodyatt, R. T., Sansum, W. D., and Wilder, R. M.: Prolonged and Accurately Timed Intravenous Injections of Sugar, J. A. M. A. **65**: 2067, 1915.
11. Wilder, R. M., and Sansum, W. D.: d-Glucose Tolerance in Health and Disease, Arch. Int. Med. **19**: 311, 1917.
12. Erlanger, J., and Woodyatt, R. T.: Intravenous Glucose Injections in Shock, J. A. M. A. **69**: 1410, 1917.
13. Matas, Rudolph: The Continued Intravenous Drip, Ann. Surg. **79**: 643, 1924.
14. Fantus, Bernard: Fluids Postoperatively, J. A. M. A. **107**: 14, 1936.
15. Fantus, Bernard: The Prescribing of Dextrose Phleboclysis, J. A. M. A. **102**: 2165, 1934.
16. Orr, T. G.: Continuous Intravenous Infusion, Minnesota Med. **18**: 778, 1935.
17. Orr, T. G.: Water and Chemical Balance in Surgery, Am. J. Surg. **18**: 279, 1932.
18. De Takats, G.: Push Fluids; the Surgeon's Postoperative Order, Am. J. Surg. **11**: 39, 1931.
19. Horsley, J. S.: The Intravenous Administration of Dextrose in Ringer's Solution, Ann. Surg. **100**: 678, 1933.
20. Gage, I. M., Ochsner, Alton, and Cutting, R. A.: Effect of Insulin and Dextrose on the Normal and on the Obstructed Intestine, Arch. Surg. **26**: 658, 1933.
21. Lusk, G., and Riche, J. A.: Metabolism After the Ingestion of Dextrose and Fat, J. Biol. Chem. **13**: 27, 1912.

BLOOD CONCENTRATION INFLUENCED BY ETHER AND AMYTAL ANESTHESIA

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THE concentration of the various elements in the blood is subject to rather wide variations under different circumstances. The rapidity of the variations in plasma volume caused by the withdrawal of water from the tissues to the blood or by the withdrawal of water from the blood to the tissues seems to be less generally appreciated. Adolph and Gerbasi studied the concentration of the blood by use of the refractive index, specific gravity and dry residue of the plasma, the hematocrit, and by use of the specific gravity and dry residue of whole blood. From these observations they calculated the dilution or concentration of the blood that occurred during amytal and urethane anesthesia. Their findings indicated that the circulating blood of dogs was greatly diluted after sodium amytal anesthesia and greatly concentrated after urethane anesthesia. This was due only in part to inflation or deflation of the spleen, respectively. The plasma was diluted or concentrated in the same direction with the corpuscular constituents, though to smaller degrees.

Evans and Gibson used the colloidal blue dye, T 1824, to determine the changes in plasma volume in diuresis. They found that the dye did not accumulate in the edema fluids of edematous dogs and thus did not invalidate the method for the determination of plasma volume. Observations of the concentration of the dye in the blood serum during diuresis induced by salyrgan indicated a diminution of plasma volume during diuresis. Their observations also indicated that, under ordinary conditions, changes in the concentration of the blood were due to shifts of water rather than to the entrance or exit of proteins in the blood.

In our studies we have determined the changes produced by ether and amytal anesthesia in the volume of the circulating plasma and in the blood and corpuscular elements. The use of the same animals in similar experiments before and after splenectomy has indicated the role of the spleen in producing such changes.

METHODS

Plasma volume was determined by calculation of the dilution produced by injection of a known amount of dye. In most experiments

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vital red was used, but in a few experiments T 1824 was used, and it gave essentially similar results. The volume of circulating blood and circulating cells was determined from the hematocrit values and plasma volume. For each determination 5 c.c. of blood was withdrawn from the jugular vein without stasis. This was added to 1 c.c. of 1.6 per cent neutral sodium oxalate in specially calibrated centrifuge tubes. Precautions were taken to avoid hemolysis, and any specimen which did not perfectly match the color of the standard solution was discarded. After centrifugation at constant speed for thirty minutes, the hematocrit values were read and the plasma was diluted and compared colorimetrically with known amounts of the dye diluted with the same amount of plasma from the animal just prior to injection of the dye.

The dogs used were maintained on a weighed standard diet, and each experiment was begun eighteen hours after the last food had been taken. Several days of training of each animal seemed necessary to accustom it to the procedure because considerable variation was found within short intervals in the hematocrit and plasma volume in the case of untrained animals. The following routine was adopted for all experiments. After the withdrawal of a preliminary sample of blood, 5 c.c. of 0.5 per cent vital red was injected, and the syringe was washed with an additional 5 c.c. of saline solution. Subsequent specimens of blood were withdrawn at intervals of from ten to fifteen minutes for about two hours. After four specimens were obtained, anesthesia was induced within a few minutes by the intravenous injection of sodium amytal or by the use of an ether cabinet, with subsequent maintenance of intratracheal ether anesthesia. Four or five specimens of blood were subsequently obtained at ten- to fifteen-minute intervals before discontinuation of the experiment.

The curve of the apparent dilution of the dye during the control period was projected back to the time of injection to obtain the original plasma volume, cell volume and blood volume. The rate of dilution of the dye during the control period was also projected forward, and deviations from this calculation were figured as changes in plasma, blood, and cell volume during the period of anesthesia. In the final calculation of the changes produced by anesthesia, the average of the four or five determinations was used.

RESULTS

Determinations of the hematocrit value, plasma volume, blood volume, and cell volume at ten- to fifteen-minute intervals for a period of two hours for each of the animals used were fairly constant. No greater variation than 6 per cent was observed in any individual hematocrit determination in any series, and the average of the determinations of the second hour on any animal was not more than 2 per

cent different from that for the first hour, which usually indicated a slight decrease in the hematocrit readings during the second hour. The dilution of the dye increased gradually during the two-hour period, so that a curve constructed by plotting the dilution with time appeared as almost a straight line. The rate of dilution of the dye, however, differed slightly in different animals and varied some in the same animal on different occasions. The disappearance of the dye from the blood, when calculated in terms of plasma volume but without allowance for the volume of blood and dye removed with each sampling, was equivalent to an increase in the plasma volume of 1 to 3 c.c. of total plasma volume each minute in the different experiments. The average plasma volume during the first hour (the average of the plasma volume at the time of injection and the subsequent determinations corrected by subtraction of the average increased dilution of dye) indicated a slight increase in the plasma volume which never exceeded 2 per cent. The greatest difference in any single specimen in one series was 7 per cent. Calculations of the blood volume and cell volume showed average figures and single differences of the same magnitude as that of the plasma volume. Similar determinations made after splenectomy showed variations of about the same magnitude.

Light amytal anesthesia produced, with few exceptions, a definite reduction in the hematocrit value. In typical experiments there was also a definite increase in the plasma volume. The decrease in the hematocrit value and the increase in the plasma volume were of about the same relative magnitude, so that the total circulating blood volume appeared but slightly changed. It was also apparent that red cells had been concentrated somewhere so that the total volume of cells in the general circulation was reduced. These changes produced by amytal anesthesia appeared within ten minutes and had usually reached their maximum within twenty minutes. No further changes occurred during the next thirty to fifty minutes, after which time a gradual return to the original levels occurred (Table I).

After splenectomy, amytal anesthesia produced a somewhat smaller decrease in the hematocrit values and about the same increase in total plasma volume as occurred in the intact dog. The total volume of circulating blood appeared to be increased and the total circulating cell volume remained unchanged from the control period (Table I).

Normal animals lightly anesthetized with ether showed a definite increase in the hematocrit value and a decrease in the total plasma volume. The changes were such that the blood volume was not greatly altered, but a greater volume of cells appeared to be in the general circulation. These changes occurred gradually and progressed with the depth of anesthesia as well as the length of time the anesthetic was administered. With deep or prolonged anesthesia, the hematocrit

TABLE I

EFFECT OF SODIUM AMYTAL ANESTHESIA

DOG	PER CENT CHANGE FROM NORMAL BEFORE ANESTHESIA				
	SODIUM AMYTAL MG. PER KG.	HEMATOCRIT	TOTAL PLASMA VOLUME	TOTAL BLOOD VOLUME	TOTAL CELL VOLUME
Normal Dogs					
1	41	−18	+11	− 0.5	−18
1	37	−11	+ 9	− 0.6	−10
2	30	−15	+19	+ 6	−11
3	40	− 8	+ 7	+ 3	− 6
4	41	− 7	+ 4	0	− 7
4	43	− 7	+ 4	0	− 7
5	32	−15	+23	+ 9	− 9
6	46	0	+14	+16	+19
6	32	− 6	+16	+10	+ 6
7	40	− 3	− 7	−10	−12
7	30	− 5	− 2	− 5	− 9
8	50	−16	+19	+ 2	−19
9	42	−11	+10	− 1	−14
10	40	0	+ 6	+ 5	+ 3
10	43	− 2	+ 4	+ 2	0
Average		− 8.3	+ 9	+ 2.3	− 6.3
Splenectomized Dogs					
2	30	− 5	+ 7	+ 3	− 3
5	25	− 5	0	− 2	− 6
9	30	− 6	+17	+14	+ 7
11	43	− 5	+14	+ 9	+ 2
11	30	− 3	+ 3	+ 2	− 1
11	50	− 8	+13	+ 5	− 3
Average		− 5.3	+ 9	+ 5	− 0.6

value did not increase as rapidly as the decrease in plasma volume, so that the total blood volume and the volume of the circulating cells was frequently decreased under these circumstances (Table II).

TABLE II

EFFECT OF ETHER ANESTHESIA

DOG	PER CENT CHANGE FROM NORMAL BEFORE ANESTHESIA			
	HEMATOCRIT	TOTAL PLASMA VOLUME	TOTAL BLOOD VOLUME	TOTAL CELL VOLUME
Normal Dogs				
1	+ 6	− 5	0	+ 8
1	+ 4	0	+ 4	+ 8
2	+ 5	+ 2	+ 6	+11
3	+10	−14	− 9	− 6
4	+10	− 7	0	+ 9
4	+ 7	− 4	0	+ 5
5	+11	− 3	+ 8	+20
6	+ 7	− 5	0	+ 4
7	+ 7	−13	− 8	− 3
9	+ 6	−16	−10	− 5
Average	+ 7.3	− 6.3	− 1	+ 5
Splenectomized Dogs				
1	+ 3	− 9	− 7	− 4
2	+ 2	−20	−20	−18
9	0	− 6	− 9	−11
11	+ 2	−28	−27	−27
Average	− 2	−16	−16	−15

Splenectomized dogs subjected to ether anesthesia showed similar changes in blood concentration, with the exception that the hematocrit values did not increase sufficiently in any experiment to indicate an increased volume of cells in the general circulation. There was usually a more marked decrease in the plasma volume and total volume of circulating blood than appeared in the intact animal under similar conditions (Table II).

On several occasions exceptions to the foregoing general findings occurred. It was observed that while the plasma volume of the individual animals at the beginning of the experiment each day was usually quite constant, variations of as much as 10 per cent sometimes occurred. Such variations, however, showed no correlation with any exceptional reaction to the anesthetic agent. Determinations of hemoglobin and blood counts have indicated that the observed changes were due to changes in the number of red cells in the circulation rather than to changes in their size.

COMMENT

Changes in the concentration of the blood under amytal and ether anesthesia have been noted by a number of observers. Seeley, Essex, and Mann, for example, found that animals were considerably less subject to traumatic shock when anesthetized with amytal than when under ether anesthesia. The influence of the spleen in abstracting red cells from the blood under amytal anesthesia has also been commented on. Our observations on the changes produced by anesthetic agents on the concentration of the cellular elements of the blood are in accord with the findings of Searles and Essex. Our data would indicate that the spleen may withhold approximately 10 per cent of the total red cells from the circulation when sodium amytal is given. The hematocrit value is further reduced by an increase in the volume of plasma in the circulation. When ether is given to produce light anesthesia, it would appear that the spleen may add red cells to the general circulation to increase the circulating cell volume by approximately 10 per cent. Greater changes than those indicated may appear in the general circulation, but since these changes also occur in the splenectomized animal, it is apparent that cells may be added to or taken from the general circulation by other capillary beds. In the dog, the spleen is evidently the most active organ in producing changes in the cellular concentration of the circulating blood. The alterations in the volume of plasma produced by anesthetic agents in this manner seem to be independent of the spleen.

No definite explanation may be given for the exceptions observed in this study. The variations observed were probably not due to inaccuracies in the methods used for the determination of the plasma and cellular volume. When the methods were checked by the rapid injec-

tion of 100 or 200 c.c. of citrated plasma, the additional fluid present three minutes after injection was accounted for within 2 per cent by calculation of the dilution produced in the concentration of the dye in the blood. When 100 to 300 c.c. of washed red cells were injected in the same way, only about 80 per cent of the injected cells appeared in the general circulation a few minutes after injection. Because of our experience with the variations in hematocrit values and blood volume observed in untrained animals we are inclined to believe that emotion may influence the circulating blood in this manner. It may be that, at times, even trained dogs were not at the same relative level of blood volume, so that subsequent changes produced by the drugs administered may have been, at times, either exaggerated or diminished. We have, however, already mentioned the fact that the absolute values found at the beginning of the experiments did not vary in the same way as the effects of the drugs varied.

SUMMARY

The dilution of the corpuscular elements of the blood during sodium amytal anesthesia is produced by the abstraction of red cells from the circulating blood by the spleen and by an increase in the fluid of the plasma. In the absence of the spleen, the dilution of the plasma is of similar magnitude as in the intact animal. Ether anesthesia produces an increase in the total circulating red cells, apparently by extrusion of these cells from the spleen and also by a diminution of the volume of circulating plasma. In the absence of the spleen fewer cells are added to the circulation, but the reduction of plasma volume seems independent of the spleen. It was obvious in a number of experiments that the volume of circulating plasma and cells may be altered by capillary beds other than those of the spleen.

REFERENCES

1. Adolph, E. F., and Gerbasi, M. J.: Blood Concentration Under the Influences of Amytal and Urethane, Am. J. Physiol. **106:** 35, 1933.
2. Evans, W. A., Jr., and Gibson, J. G., Jr.: The Blood Volume in Diuresis: Study Employing Colloidal Blue Pheresis, Am. J. Physiol. **118:** 251, 1937.
3. Seeley, S. F., Essex, H. E., and Mann, F. C.: Comparative Studies on Traumatic Shock Under Ether and Under Sodium Amytal Anesthesia: An Experimental Research, Ann. Surg. **104:** 332, 1936.

THE OPERATIVE TECHNIQUE OF CAROTID-JUGULAR ANASTOMOSIS

An Experimental Study

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PRELIMINARY to undertaking certain experimental studies on arteriovenous fistulas, with special reference to those of the large vessels of the neck, it was deemed advisable to make a comparative study of the various merits of the end-to-end, end-to-side, and side-to-side carotid-jugular anastomoses. Although numerous reports have been published on the various methods employed in accomplishing anastomosis of blood vessels and on the local and general effects of such anastomosis, the literature is replete with evidence that investigators are unable as yet to consistently make anastomoses which function perfectly and which will continue to do so indefinitely.

Eck seems to have been the first to accomplish anastomosis of blood vessels. While investigating the physiology of the liver in 1879, he performed a successful lateral anastomosis between the portal vein and vena cava of dogs. His technique resembled somewhat that employed in making a lateral intestinal anastomosis, except that the stoma was not made until all sutures had been placed. For this purpose he employed a small pair of scissors, to each tip of which was soldered a fine piece of wire terminating in a curved needle. Following the placing of the posterior line of sutures, these needles were passed in a longitudinal direction through the vessels (one through the portal vein, the other through the vena cava) at points determined by the size of the stoma desired. The anterior line of sutures was then placed, the blades of the scissors were pulled into the vessels by means of the wires, and the veins were cut between the two lines of sutures. This technique was improved by Stolnikow in 1882, by Hahn, Massen, Nencki, and Pawlow in 1893, and by others. The stoma is now generally made by means of a cutting suture. The subject of the Eck fistula indeed forms an important chapter in the history of surgery of blood vessels.

In 1888, von Horoch attempted to suture together the ends of a severed artery, but he was unable to do so without interfering with the patency of the vessel. Abbe, who published his results in 1894, was apparently the first to become interested in experimental studies

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concerned with the circular suturing of arteries. He reunited the severed femoral artery of a dog by tying the ends together over a small tube of thin glass similar to an hourglass in shape. The circulation of the leg was immediately reestablished as soon as the clamps were removed from the artery and the prognosis seemed favorable. However, when the artery was removed and examined some time later, the tube was found lying free in the lumen of the vessel which had become occluded a short distance distally. In 1897, Nitze demonstrated some small ivory cylinders over which the ends of the divided vessel might be slipped in such a manner as to approximate the intima of the proximal portion to that of the distal portion. Such an anastomosis could be held in position by means of a single ligature. Payr,[26] in 1900, devised a similar anastomotic prosthesis consisting of a hollow cylinder of magnesium. Payr[27] and Höpfner both championed this device and expressed the opinion that a good share of its efficacy was owing to the fact that the type of magnesium used was readily absorbable. Jensen, Reinsholm, and others, however, were unable to obtain successful anastomoses with the use of prostheses.

In 1896, Jaboulay and Briau experimented with circular suturing of carotid arteries of dogs, the ends of the vessels being united with U-shaped sutures which everted the edges and approximated intima to intima. None of their ten operations on dogs was successful, all of the vessels becoming thrombosed; but later Briau and Jaboulay had perfect success with this method on a larger vessel, namely, the carotid artery of a donkey.[3] Salomoni, in 1900, devised a similar technique. In 1897, Murphy published an interesting article in which he detailed his numerous experiments with suturing arteries and described a new method for reuniting severed vessels. This method consisted of invaginating the proximal end into the distal end and retaining the invagination by means of silk sutures.* Although considerable success was reported to have accompanied the use of this method by Murphy and by Bouglé, the famous method of circular suturing described by Carrel in 1902 soon became the standard procedure.

Gluck reported the first successful arteriovenous anastomosis in 1883. He united the carotid artery and the jugular vein of a dog by means of a circular suture without the formation of a thrombus. In 1902, San Martin and Satrustegui performed forty arteriovenous anastomoses on dogs, operating by preference in the groin but also in the neck and in other regions traversed by large blood vessels. He united the proximal end of the artery and the distal end of the vein by invaginating the artery into the vein and suturing with catgut. All of the dogs stood

*Wieting described his "intubation" method of arteriovenous anastomosis in 1908 and recommended it for the treatment of gangrene of the lower extremity. In this operation the proximal end of the femoral artery was invaginated into the side of the femoral vein much in the same manner as Murphy would have invaginated it into the distal end of the vein.

the operation well, except those in which the peritoneum was invaded; but death occurred from hemorrhage, thrombosis, or infection in a few hours or a few days. The longest period of function obtained was eight days. In 1902, Carrel and Morel[8, 9] succeeded in making an anastomosis between the proximal end of the carotid artery and the distal end of the external jugular vein of a dog, without the subsequent formation of a thrombus. In the several months during which the animal was under observation, the results remained satisfactory. In 1905, the experiments begun in France by Carrel and Morel were continued in this country by Carrel and Guthrie.[6, 7] With improved technique, various arteriovenous anastomoses were made with very successful and interesting results.[5] Subsequent noteworthy papers were those of Watts, Reid, Lewis and Drury, Holman,[17, 18] Harrison and co-oworkers, and Voss.

METHODS

Carotid-jugular anatomosis was performed on twelve dogs. In two dogs end-to-end anastomosis was made between the proximal end of the left common carotid artery and the proximal end of the right external jugular vein (Group 1). In two dogs an anastomosis was made between the proximal end of the right common carotid artery and the side of the right external jugular vein (Group 2). In another pair of dogs lateral anastomosis was made between the right common carotid artery and the right external jugular vein (Group 3). Group 4 consisted of six dogs in which the proximal end of the right common carotid artery was united to the distal end of the right external jugular vein. The dogs ranged in size from 11 to 24 kg. The operations were performed under aseptic conditions. Ether was employed according to the autoinhalation technique devised by McGrath and later modified and described by Mann and by Hardenbergh and Mann. All the wounds healed by primary intention. Immediately following the operation, a continuous bruit with distinct systolic accentuation could be heard over the point of the anastomosis in each instance and after subsidence of the initial edema a thrill could be easily ascertained. This paper deals only with the operative technique and the results of operation relevant to the duration of function of the fistulas.

OPERATIVE TECHNIQUE

The technique of making anastomoses between blood vessels in this laboratory is directed, with certain modifications, toward simplification. It is very much like the method which was first devised by Carrel[4] and later described at some length by Ehrenfried and Boothby. It is essentially a method of circular suturing in which the cut end of each vessel is first pulled into the shape of a triangle by means of traction made on three stay sutures.

For all types of anastomosis of blood vessels in the neck, a generous incision is made in the midline. The vessels to be anastomosed are exposed by blunt dissection and are carefully cleaned by using smooth forceps. When the anastomosis is to be performed between an artery and vein of the same side of the neck, the artery, in all cases, should be passed laterally behind the sternomastoid muscle, after the posterolateral border of this muscle has been freed from its bed. In this manner the artery may be brought into parallel juxtaposition with the vein, with the result that the flow of blood in the vessels after the anastomosis has been completed is not hampered by distortion of either of the component vessels. If special attention is paid to this detail of the operative procedure and to accurate alignment of the artery and vein so that twisting of these vessels does not occur at the time of placing the sutures, many fistulas will function over long periods of time.

When the vessels have been properly cleaned, serrefines are placed proximal and distal to the point at which the vessel is to be severed. Special attention should be paid to the serrefines employed in operating on blood vessels. The blades should be shod with rubber and the tension of the springs should be weakened by filing to such an extent that the blades come together with force sufficient only to occlude the blood stream. If these precautions are not taken, any amount of skilled technique and postoperative care will not suffice to prevent the thrombosis which will occur owing to the injury wrought on the intima by the external pressure of the serrefines. Great care likewise should be exerted in the placing of the serrefines; and the two serrefines on each vessel should be placed at a distance of at least 4 or 5 cm. from one another. In applying the serrefines to the artery, one should be placed proximal to the point of division first; then, after milking the blood peripherally by a gentle stripping motion, one should be placed distal to the point of division. In applying serrefines to the vein, the reverse procedure is followed; thus, a serrefine is applied distal to the point of division first, and, after emptying the blood centripetally by pressure from without, a serrefine is applied proximal to the point of division. In performing an end-to-end anastomosis, hemostats may be employed in place of the distally situated serrefine on the artery and in place of the proximally situated serrefine on the vein. After the vessels have been severed, the stumps secured by the hemostats are doubly ligated and are allowed to recede into the wound.

Either a scalpel or a fine pair of scissors may be employed for dividing the vessels. The important thing is that the instrument chosen should be very sharp. In performing an end-to-end anastomosis, the vessel is held firmly by means of smooth forceps and is cut quickly

and cleanly with one movement in order that the edges of the incision may be smooth, even, and perpendicular to the long axis of the vessels. The vessels to be anastomosed should be divided at such a point that the resulting length of the stumps will allow them to overlap each other by at least 2 or 3 cm. This aids the operator considerably in bringing the ends together without undue tension and further gives him the assurance that undue tension will not develop postoperatively. For it must be borne in mind that the carotid artery of the dog has a tendency to retract considerably after it has been severed. If there is considerable tension on the line of anastomosis following operation, there will be an increased likelihood that hemorrhage will occur or, owing to narrowing of the lumens of the vessels as a result of the increased tension, that thrombosis will occur.

In this laboratory, it has been found that, when making an end-to-end anastomosis of the great vessels on the same side of the neck, the performance of the operation is materially facilitated by separating the vessels which are to be anastomosed from the remainder of the operative field by a piece of dry gauze. The ends of the vessels must be kept moist at all times with mineral oil which has been sterilized and which may be applied by means of a medicine dropper. Mineral oil is superior to a saline solution in its ability to spare the vessels from the effects of desiccation. The ends of the vessels are prepared for anastomosis by carefully removing any of the adventitia which might interfere with approximation of intima to intima. This may be done with small forceps that have blunt or rounded tips or with gauze, by drawing the adventitia over the cut end of the vessel and clipping it off with small scissors. Clean, smooth edges may be obtained in this manner. The three stay sutures are now placed at equidistant points about the circumference at the ends of the vessels, taking particular care that the posterior stitch is indeed at the most posterior point of both the artery and the vein. This is one of the most essential precautions to be followed in the entire operation, for unnatural twisting of the vessels will invariably lead to thrombosis. Each stay suture includes the full thickness of the wall of each vessel and should be inserted in such a manner as to allow the knot to be outside the vessel. Also, all three sutures are drawn up simultaneously to avoid tearing or stretching of any part of the circumference and by this maneuver the cut edges of both vessels are approximated. While the assistant holds two of them taut, the operator ties the third, gently but snugly. Japanese white silk (No. 000) on small straight needles that are approximately 1 cm. in length have been used in this laboratory for many years.* Specially designed small needle holders may be employed, but mosquito forceps are very satisfactory.

*In the past we have obtained these materials from the Sankyo Company, Muromachi, Nihombarshi-Ku, Tokyo, Japan.

The next step is the placing of the continuous sutures which are to complete the anastomosis. During this process, the assistant holds the three stay sutures taut so that the circular shape of the end of each vessel is converted into that of a triangle (Fig. 1). The assistant must pay special attention to that stay suture which is at the angle opposite the segment of the triangular edge which the operator is at that time suturing; otherwise the under wall of the vessels may be pulled up against the upper and the two sewn together. If the stay sutures are held properly, difficulty is not experienced in placing the continuous stitch. This is nothing more than an over-and-over running stitch

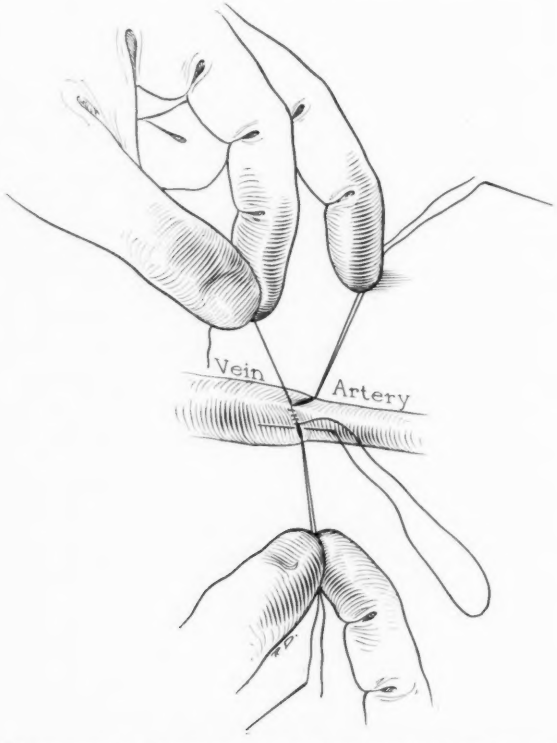

Fig. 1.—Semidiagrammatic drawing illustrating carotid-jugular anastomosis. The stay sutures have been tied and the anterior continuous suture is being placed. The manner in which stay sutures are held by the assistant is illustrated. The vessels are enlarged approximately three times their normal size for the sake of clarity.

which is made with the very same needles and sutures that were initially used for the stay sutures. The operator pulls up the slack of this running suture after each stitch is placed. With a certain amount of care the edges may be everted and the intima of one vessel approximated to that of the other. Four to six stitches will suffice for each side of the triangular edge.

When the anastomosis is completed, the free ends of the sutures are left long (in case it should be found necessary to repair any part of the anastomotic ring) and the serrefines are removed. That serrefine

which is on the side of low pressure (the venous side) is removed first. If the anastomosis appears to be competent, the serrefine on the side of high pressure is removed. There is nearly always some leakage of blood. As a rule this occurs around the stay sutures where the vessels have been stretched by the tension exerted on these sutures. This oozing may be controlled easily, however, by applying slight pressure with the gloved fingers over the site of anastomosis for a matter of only half a minute or less. Even defects of such a size as to permit the escape of a spurting stream of blood may be similarly controlled. Gauze is not nearly so effective in this respect as is the gloved finger, for the thrombi which form and thus efficiently prevent the escape of blood are torn loose when the gauze is removed. If bleeding cannot be controlled by pressure, the defect may be repaired with silk. All sutures are then cut and the posterior border of the upper portion of the sternomastoid muscle is sutured back into its bed by means of two or three interrupted stitches of No. 2 catgut. Care is taken to leave a sufficient amount of room behind the lower portion of this muscle to prevent pressure on the carotid artery. Suturing the sternomastoid muscle in this manner places the fistula directly beneath the skin and relevant physical signs thus may be easily noted. The wound is closed with a continuous subcutaneous stitch of No. 2 catgut and a continuous cutaneous stitch of linen.

The technique of side-to-side anastomosis of vessels differs but little from that of end-to-end anastomosis. After the carotid artery has been brought out beneath the sternomastoid muscle, the vessels have been properly aligned and the serrefines have been applied, small scissors (or a sharp scalpel) are employed to cut through the wall of the vessel. This incision should be made at least half way through the diameter of the vessel in order that the completed stoma may be as large as the diameter of the smaller vessel. The incision should be exactly perpendicular to the long axis of the vessel and, of course, should be on the lateral aspect of the artery and on the medial aspect of the vein, respectively. As in the case of end-to-end anastomosis, three stay sutures are employed. In this instance, however, the first stay suture is placed in such a manner that when it is drawn up, the posterior edges of the two incisions made in the vessels will be approximated; the other two are placed, one proximally and the other distally, in such a manner that when they are drawn up the vessels will be brought together at a point approximately two-thirds the distance from the posterior angles of the incisions to the anterior angles. The continuous sutures are then placed as in the case of end-to-end anastomosis.

End-to-side anastomosis is merely a combination of the two techniques previously outlined. In anastomosing the left common carotid

artery and the right jugular vein, the vessels are brought together over the right sternomastoid muscle.

RESULTS

The fistulas of the dogs of Groups 1 and 2 closed in three to six weeks (Table I). Following closure of the fistulas, an exploratory operation was performed in each instance and the region of anastomosis with approximately 3 cm. of vein and 3 cm. of artery were excised for study. Careful examination of these specimens revealed that thrombosis was not the cause of closure in any case. Both vein and artery contained blood in the fluid state up to the point of anastomosis and blood flowed freely from both the vein and the artery

TABLE I

DURATION OF CAROTID-JUGULAR FISTULAS

GROUP	TYPE OF ANASTOMOSIS	DOG	WEIGHT, KG.	RESULTS
1	Proximal end of the left common carotid artery to proximal end of right external jugular vein	1	16	Closed at 5 wk.
		2	15	Closed at 6 wk.
2	Proximal end of the right common carotid artery to the side of the right external jugular vein	3	11	Closed at 4 wk.
		4	17	Closed at 3 wk.
3	Side-to-side anastomosis between the right common carotid artery and right external jugular vein	5	16	Broke down on third day
		6	22	Broke down on eighth day
4	Proximal end of the right common carotid artery to the distal end of the right external jugular vein	7	24	Functioning at 41 wk.
		8	15	Functioning at 41 wk.
		9	18	Functioning at 40 wk.
		10*	14	Functioning at 30 wk.
		11	23	Functioning at 29 wk.
		12†	14	Functioning at 19 wk.

*Specimen removed surgically (Fig. 2).
†Animal died. Cause unrelated to vascular anastomosis. Fistula patent.

when the specimen was removed for study. The cause of closure was constriction of the anastomotic ring. This was probably caused by interference with the flow of blood which in turn was caused by pressure from without, by distortion inherent in the method of anastomosis used in these two groups of dogs and by tension owing to retraction of the carotid artery. In employing these two methods of anastomosis (especially that of end-to-side anastomosis) retraction of the carotid artery is difficult to avoid. If a sufficient length of carotid artery is not employed to allow for the retraction which occurs during the ensuing few days, the consequent distortion of the vessel will have an undesirable effect on the blood flow and survival of the fistula.

The fate of the anastomosis was identical in the cases of both dogs of Group 3. Breakdown of the fistula of Dog 5 occurred on the third

day and that of Dog 6 on the eighth day. This breakdown is to be expected fairly regularly in cases of side-to-side anastomosis of the great vessels of the neck and is attributable to the constant sawing action caused by the forceful pulsation in the carotid. This catastrophe makes itself evident by causing great swelling of the entire neck owing to extravasated blood and prostration of the animal develops rapidly. Dog 6 died almost immediately and at necropsy not only was there a massive hematoma in the neck, but also the posterior mediastinum was distended with blood as far down as the diaphragm. Dog 5 survived and, after absorption of the huge hematoma had occurred, an exploratory operation was performed. The carotid artery had been torn loose from the jugular vein, had itself torn into two parts at the site of the former anastomosis, and had retracted into its normal bed. Both of the torn ends were filled with a gray thrombus and were separated from one another by a distance of approximately

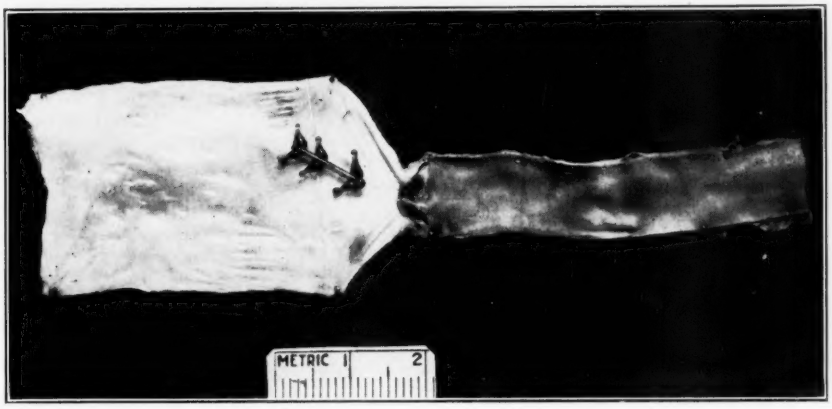

Fig. 2.—Specimen removed surgically from Dog 10, showing aneurysmal dilatation of both the carotid artery and jugular vein.

3 cm. Remnants of sutures were found in the central portion of the thrombus. The former anastomotic stoma in the vein was represented by nothing more than a dimple. The vein itself was functioning normally.

All six dogs of Group 4 had functioning fistulas at the time this paper was prepared. A distinct bruit and thrill could be made out on the right side of the neck of every dog of Group 4. In three instances considerable tortuosity and aneurysmal dilatation of the jugular vein were present.

SUMMARY

A brief review of the literature dealing with the technique of anastomosis of blood vessels is presented. The technique employed in this laboratory (a modification of the method developed by Carrel and Guthrie) is described in some detail. The results of carotid-jugular

anastomosis performed on twelve dogs are given. In two of these twelve dogs the proximal end of the right common carotid artery was anastomosed to the proximal end of the left external jugular vein. In two other dogs an end-to-side anastomosis was made between the right common carotid artery and the right external jugular vein. All four of these fistulas functioned well at first but closed in three to six weeks. The cause of closure was contraction of the anastomotic ring, not thrombosis. A side-to-side anastomosis between the right common carotid artery and the right external jugular vein was performed on two dogs; both of these anastomoses broke down (one on the third day and the other on the eighth day) owing to the constant sawing action exerted on the line of suture by the forceful pulsation of the carotid artery. An end-to-end anastomosis between the proximal end of the right common carotid artery and the distal end of the right external jugular vein was performed on the remaining six dogs. At the time this paper was prepared, these anastomoses had all been functioning perfectly for nineteen to forty-one weeks.

REFERENCES

1. Abbe, Robert: The Surgery of the Hand, New York M. J. **59**: 33-40, 1894.
2. Bouglé, J.: La suture artérielle; étude critique et expérimentale, Arch. de med. expér. et d'anat. path. **13**: 205-224, 1901.
3. Briau and Jaboulay: Suture artérielle, Lyon méd. **87**: 305, 1898.
4. Carrel: La technique opératoire des anastomoses vasculaires et la transplantation des viscères, Lyon méd. **98**: 859-864, 1902.
5. Carrel, Alexeis: The Surgery of Blood Vessels, etc. Bull. Johns Hopkins Hosp. **18**: 18-28, 1907.
6. Carrel, Alexis, and Guthrie, C. C.: De la transplantation uniterminale des veines sur les artères, Compt. rend. Soc. de biol. **59**: 596-597, 1905.
7. Carrel, Alexis, and Guthrie, C. C.: Résultats éloignés de la transplantation veineuse uniterminale, Compt. rend. Soc. de biol. **60**: 529-530, 1906.
8. Carrel and Morel: Anastomose bout a bout de la jugulaire et de la carotide primitive, Lyon méd. **99**: 114-116, 1902.
9. Carrel and Morel: Présentation d'un chien porteur d'une anastomose artério-veineuse, Lyon méd. **99**: 152-153, 1902.
10. Eck: Quoted by Stolnikow.
11. Ehrenfried, Albert, and Boothby, W. M.: The Technic of End-to-End Arterial Anastomosis: With Report of a Case, Ann. Surg. **54**: 485-495, 1911.
12. Gluck, Th.: Ueber zwei Fälle von Aortenaneurysmen nebst Bemerkungen über die Naht der Blutgefässe, Arch. f. klin. Chir. **28**: 548-555, 1883.
13. Hahn, M., Massen, O., Nencki, M., and Pawlow, J.: Die Eck'sche Fistel zwischen der unteren Hohlvene und der Pfortader und ihre Folgen für den Organismus, Arch. f. exper. Path. u. Pharmakol. **32**: 161-210, 1893.
14. Hardenbergh, J. G., and Mann, F. C.: The Auto-Inhalation Method of Anesthesia in Canine Surgery, J. Am. Vet. M. A. **71**: 493-501, 1927.
15. Harrison, T. R., Dock, William, and Holman, Emile: Experimental Studies in Arterio-Venous Fistulae; Cardiac Output, Heart **11**: 337-341, 1924.
16. Höpfner, Edmund: Ueber Gefässnaht, Gefässtransplantationen und Replantation von amputirten Extremitäten, Arch. f. klin. Chir. **70**: 417-471, 1903.
17. Holman, Emile: Experimental Studies in Arteriovenous Fistulas. I. Blood Volume Variations, Arch. Surg. **9**: 822-836, 1924.
18. Holman, Emile, and Kolls, A. C.: Experimental Studies in Arteriovenous Fistulas. II. Pulse and Blood Pressure Variations, Arch. Surg. **9**: 837-879, 1924.
19. Jaboulay, M., and Briau, E.: Recherches expérimentales sur la suture et la greffe artérielles, Lyon méd. **81**: 97-99, 1896.
20. Jensen, Georg: Ueber circulare Gefasssutur, Arch. f. klin. Chir. **69**: 938-999, 1903.

21. Lewis, Thomas, and Drury, A. N.: Observations Relating to Arterio-Venous Aneurism. Part II. The Immediate Effects of an Arterio-Venous Anastomosis on the Dog's Circulation, Heart **10**: 365-389, 1923.
22. Mann, F. C.: Anesthesia in Experimental Surgery, Am. J. Surg. **34**: 11-16, 1920.
23. McGrath, B. F.: Anesthesia in Surgical Research: A Simple, Economical and Efficient Apparatus for Ordinary Routine Work, Surg., Gynec. & Obst. **18**: 765-766, 1914.
24. Murphy, J. B.: Resection of Arteries and Veins Injured in Continuity—End-to-End Suture—Experimental and Clinical Research, M. Rec. **51**: 73-88, 1897.
25. Nitze: Discussion, Centralbl. f. Chir. **24**: 1042, 1897.
26. Payr, Erwin: Beiträge zur Technik der Blutgefäss- und Nervennaht nebst Mittheilungen über die Verwendung eines resorbirbaren Metalles in der Chirurgie, Arch. f. klin. Chir. **62**: 67-93, 1900.
27. Payr, Erwin: Zur Frage der circulären Vereinigung von Blutgefässen mit resorbirbaren Prosthesen, Arch. f. klin. Chir. **72**: 32-54, 1904.
28. Reid, M. R.: The Effect of Arteriovenous Fistula Upon the Heart and Blood-Vessels; an Experimental and Clinical Study, Bull. Johns Hopkins Hosp. **31**: 43-50, 1920.
29. Reinsholm, Wilhelm: Die verschiedenen Methoden für cirkuläre Vereinigung abgeschnittener grösserer Arterien- und Venenstämme, Nord. med. Ark. **36**: 107-144, 1903.
30. Salomoni: Quoted by Watts, S. H.
31. San Martin and Satrustegui: Quoted by Carrel, Alescis.
32. Stolnikow: Die Stelle vv. hepaticarum im Leber- und gesammten Kreislaufe, Arch. f. d. ges. Physiol. **28**: 255-286, 1882.
33. Von Horoch: Die Gefaessnaht, Allg. Wien. med. Ztg. **33**: 263-264; 279-280, 1888.
34. Voss, O.: Beitrag zur arterio-venösen Anastomose, Beitr. z. klin. Chir. **159**: 414-423, 1934.
35. Watts, S. H.: The Suture of Blood Vessels. Implantation and Transplantation of Vessels and Organs. An Historical and Experimental Study, Bull. Johns Hopkins Hosp. **18**: 153-179, 1907.
36. Wieting: Die angiosklerotische Gangrän und ihre operative Behandlung durch arteriovenöse Intubation, Deutsche med. Wchnschr. **2**: 1217-1221, 1908.

UNILATERAL HYPERTROPHY OF THE MANDIBULAR CONDYLE ASSOCIATED WITH CHONDROMA

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THE occurrence of unilateral hypertrophy of the mandible in association with tumors of the condyle is a rather rare syndrome. The following case presents some interesting features in diagnosis and treatment.

CASE REPORT.—N. C., unemployed white male, aged 22 years, was first seen in the University of Chicago Clinics, Feb. 26, 1931, with the complaint that, beginning about 10 years previously, he had noted a painless increasing deformity of the lower jaw with deviation of the mandible to the left and corresponding change in the articulation of the teeth. He had been examined a number of times elsewhere without a diagnosis having been made or treatment recommended.

Past History.—The patient had measles and mumps as a child, exact age unknown, without any complications directly following these illnesses. At the age of 10 years, he inadvertently stepped on the electrically charged rail of an elevated track, receiving a shock which threw him to the ground leaving him unconscious for several minutes. There was no known trauma to the face or jaw at this time. At the age of 17 years he had three first molar teeth extracted for dental caries.

Physical Examination.—The significant findings were limited to the head. The mandible was markedly deviated to the left. There was no restriction to movement of the jaw; on opening the mouth, all movement took place from the left condyle, the right acting solely as a pivotal point. With the teeth in occlusion, the midline of the upper jaw coincided with the space between the lower right cuspid and lateral incisor, a deviation of 12 mm. to the left. On opening the mouth, the midlines of the upper and lower jaws were seen to correspond, indicating the presence of rotary motion at the right condyle and pointing to it as the source of the trouble. X-rays taken at this time exhibited a malformation of the right condyle with partial extrusion out of the glenoid fossa. The skull and sella turcica were normal in size and formation. The remainder of the skeleton seemed to be entirely within normal limits. The Wassermann and Kahn reactions were negative. He was seen at this time by Dr. A. G. Brodie, of the Department of Orthodontia, University of Illinois, and a diagnosis of overgrowth of the mandibular condyle (right) was made. Treatment was discussed with the patient, but he did not return and was not seen again until Oct. 24, 1937 (Fig. 1). At this time he felt that the deformity had increased somewhat since 1931. He was having difficulty holding a job because of his marked facial deformity. Examination indicated that the midline of the upper jaw now corresponded to the middle of the lower right cuspid, a deviation of 15 mm. to the left, or an increase of 3 mm. in the deformity since his last examination (Fig. 2). With the mouth closed, only three teeth of the lower jaw were in contact with the upper arch; these were the lower right second and third molars and the

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Fig. 1.—Appearance of the patient prior to operation. Note the deviation of the chin to the left side and the prognathism.

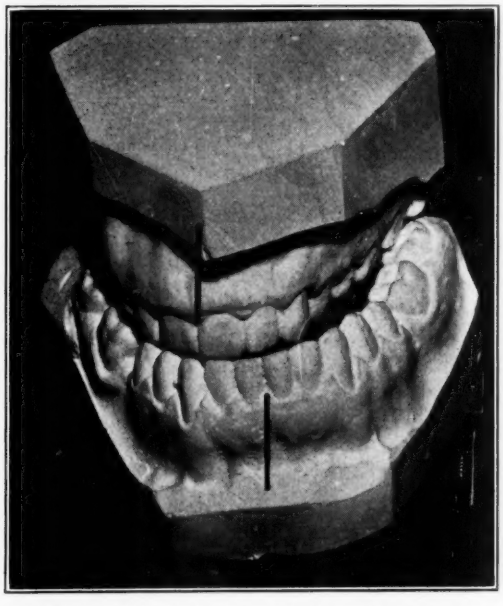

Fig. 2.—Plaster models of the teeth in occlusion prior to operation. The vertical lines indicate the midlines of both upper and lower jaws. Note that two molars are the only teeth in apposition of the left side.

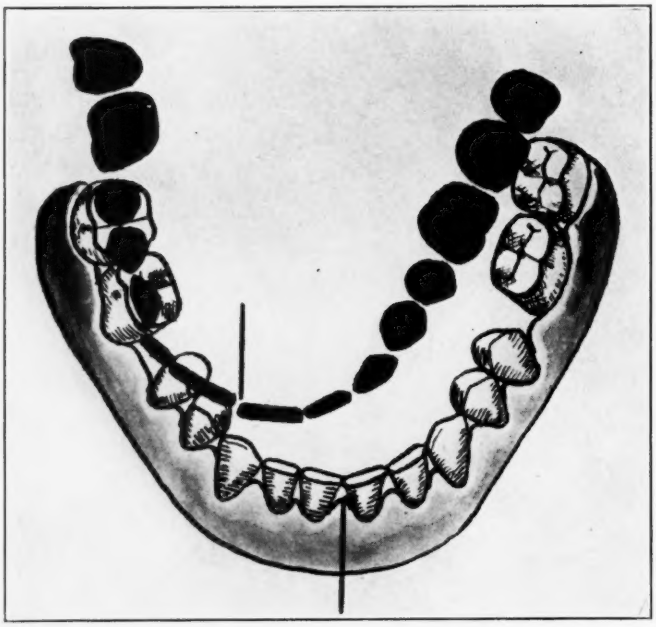

Fig. 3.—Drawing to illustrate the relationship of the upper to the lower teeth prior to operation. The solid black represents the upper teeth. The two vertical lines indicate the midlines of maxilla and mandible.

Fig. 4.—X-ray of right mandible showing greatly enlarged condyle outlined.

Fig. 5.—Postoperative appearance of the patient; restoration of normal profile and correction of facial asymmetry by removal of the hypertrophic right mandibular condyle.

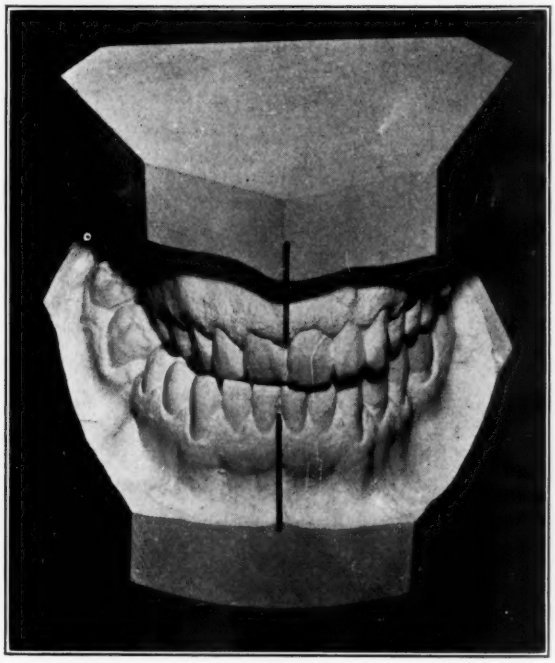

Fig. 6.—Occlusion of the teeth after removal of the hypertrophic right condyle and rotation of the mandible into a more normal position. The lower left posterior teeth have been built up with crowns. Compare with Fig. 2.

lower left third molar (Fig. 3). Measurements of the ramus of the mandible from the condyle to the angle indicated the right side to be 9.6 cm. and the left to be 7.3 cm. The right condyle was more prominent than the left and was easily palpated. X-rays at this time revealed approximately the same deformity of the condyle previously noted (Fig. 4). In addition to the mandibular deformity, it was evident that the left eye and orbit were somewhat lower than the right. The patient entered the hospital for treatment.

Operation.—Under ether anesthesia, a hockey-stick incision with a long horizontal limb was made, exposing a greatly enlarged condyle. This was removed intact by making a series of drill holes low in the neck of the condyle, and then severing the remaining bone with a chisel. The joint cavity and meniscus left behind appeared quite normal, and the wound was closed in layers. The jaw could now be freely moved to a more normal position and the facial asymmetry disappeared (Fig. 5). Later in the day, after the patient had recovered from the effects of anesthesia, the upper and lower jaws were fixed together in the new position with

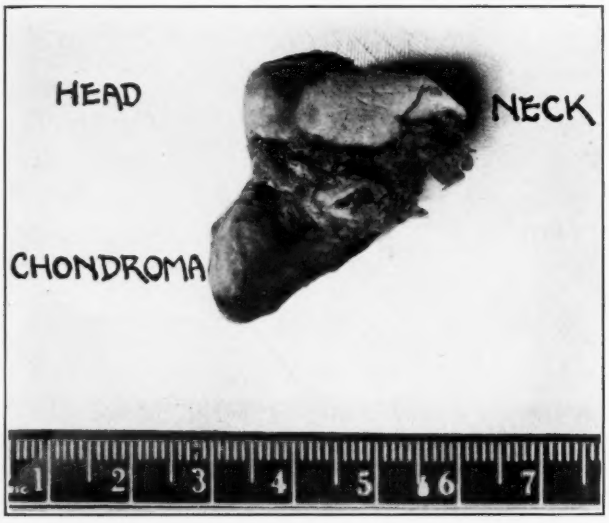

Fig. 7.—Condyle removed at operation; both head and neck were greatly enlarged and on the anterior aspect of the condyle was the cartilaginous enlargement shown.

intermaxillary wires. These were changed two days later for intermaxillary elastics which permitted movements of the mandible, but tended to hold it in its new position by the tension of small rubber bands connected to arch wires fastened to the labial surfaces of the teeth of both jaws (Fig. 6). Following operation, some paresis of the supraorbital musculature was noted; the right eye could be closed, but not as vigorously as the left. This condition persisted for about six weeks, with gradual improvement until at the present time no weakness remains.

Pathologic Examination.—The specimen consists of a large condyloid process of the mandible which measures 1.8 cm. in length, 2.2 cm. in anteroposterior direction and is 2 cm. thick (Fig. 7). The articular surface appears normal; there is a large mass on the anterior aspect of the condyloid process that looks like an osteocartilaginous exostosis.

Microscopic.—The section is through the entire condyle. The articular surface is covered with fibrocartilage; near the tip of the condyloid process is a large area of hyaline cartilaginous proliferation which is capped by fibrocartilage. In this region, the bony trabeculae are mixed with sheets of cartilage cells. The remainder of the

section is composed of thin, bony trabeculae and hematopoietic marrow. Pathologic diagnosis: Chondroma of mandibular condyle.

DISCUSSION

A review of the literature indicates that considerable confusion exists regarding this condition. In the German journals, which contain the most complete accounts of this disease, it is spoken of as "hyperostotischer schiefer Bisz" or in certain other reports as "chronische deformierender Arthritis." Reports of 44 cases of this type have been found in the literature. Eckert in 1899 reported a case of osteoma of the mandibular condyle with typical asymmetry of the face and collected 18 other previously reported cases. Voelker (1907) reported a similar case. Hofer (1922) describes two cases, one of which was verified by operation; each of these cases seemed to be exostoses of the condyle. The early literature on this subject is reviewed and briefly reported by Gruca and Meisels (1926), who add an additional case of their own. Dufourmentel (1929) gives a short discussion of this disease in his monograph on the surgery of the temporomandibular articulation. Ivy (1927) reported one case of cyst of the condyle and two cases of bony enlargement of the condyloid process, all of which were treated by excision of the deformed bone. Pichler describes a case of this kind in an 18-year-old boy, successfully treated by condylar resection. In their monograph on injuries and diseases of the jaws, Perthes and Borchers discuss hypertrophy of the condyle. In an early edition of this work Perthes described six cases to which Borchers now adds one more. This condition is differentiated in their text from that of arthritis deformans of the mandible. The exact criteria for this differentiation is not clear and it seems unlikely that the changes ascribed to arthritis deformans differ from those of osteoma or idiopathic bony overgrowth of the condyle. Sonntag (1934), in a discussion of diseases of the temporomandibular joint, comments on the rarity of the condition but introduces no cases of his own. Oehlecker (1936) reports a marked case of osteoma of the condyle treated by resection of the involved head and neck of the mandible. In this case, occlusion of the upper incisor teeth was taking place in the molar region of the opposing jaw before operation.

Description of the Disease.—These mandibular deformities result from abnormalities of the temporomandibular articulation. The disease occurs most frequently in young adults; the range of ages in reported cases was from 8 to 81 years, but generally the cases fell in the age group between 20 to 35 years. In 37 cases in which the sex of the patient was mentioned, 18 were males and 19 females. In a smaller series of cases reported by Perthes and Borchers, Gruca and Meisels, and Sonntag, it was reported that the disease predominates in females. However, examination of this larger series shows that the incidence is about equally divided between the two sexes. A slowly progressive, unilateral,

painless change in the size of the mandible develops, associated with deformity of the face and malrelation of the teeth. There is deviation of the chin to the normal side, and a characteristic "crooked bite" results. There may be pain and crackling in the affected temporomandibular joint, but in general the attention of the patient is attracted by the increasing facial deformity and the difficulty in chewing properly. There is no limitation to movements of the jaw—the mouth can be fully opened, but lateral movements of the mandible arising from the affected condyle could not be performed in our case.

The etiology of this condition is not clear; Pichler considers these rare cases to be examples of growth anomalies. Several of the reported cases were associated with chronic middle-ear disease and Eiselsberg assumes that a chronic arthritic process with bony change takes place in the temporomandibular joint. In our case there was no history or evidence of middle-ear disease. Hofer reports his cases as examples of arthritis deformans. This view is not held by Gruca and Meisels and Oehlecker, who feel that the etiology is essentially unknown, and that it is unwise to classify these changes as arthritic on the basis of present evidence. Gruca and Meisels suggest that an inflammatory hyperemia of long standing (as chronic otitis media) may initiate epiphyseal overgrowth. They also consider the influence of trophic changes on facial hemihypertrophy and abnormal intrauterine position on the development of this disease.

It seems evident to us from a study of our case and a review of the literature, that the condition is associated with one of three pathologic processes in the condyle: (1) chondroma, (2) cyst, or (3) osteoma. Since the condyle is the seat of one of the mandibular growth centers, it seems likely that occasionally a cartilaginous rest may remain and in later years resume growth, thus accounting for the chondromatous tumors noted in several of the reported cases. Ivy's case is the only one reporting a condylar cyst, and the etiology of this is quite obscure. The formation of osteomas elsewhere on the jaws is not rare and is without definite etiological association. It is well known, however, that bony overgrowths may take place in the condyloid process in the presence of chronic otitis media or following trauma to the mandible. Cases of true bony ankylosis of the jaws are frequently found to be associated with such conditions. The following illustration is indicative of this.

CASE REPORT.—A. S., white female, aged 13 years, was seen at the University of Chicago Clinics complaining of inability to open the mouth. The patient was apparently well until six years previously when she was struck by an automobile, sustaining a fracture of the left leg and a questionable fracture of the right mandible. Since that time, progressive limitation of motion of the jaw has been present. There was no pain at any time except on chewing hard foods, when some tenderness of the right condylar region would be present. The past history was otherwise negative.

Physical Examination.—The significant findings were limited to the face. The patient had a typical "bird face" deformity with receding mandible. Attempts to open the mouth were attended with movement of the mandible to the right side. The teeth could be separated about 3 mm. at the incisal region. There was a moderate overbite of the maxillary teeth. X-rays indicated a normal appearing left temporomandibular joint; the right condyle was larger than the left and presented diffuse sclerosis about the joint. A diagnosis of ankylosis of the temporomandibular joint (right) was made and the patient entered the hospital for treatment.

Operation.—Under ether anesthesia the usual hockey-stick incision was made exposing an enlarged condyle with obliterated joint space. The bony overgrowth was continuous with the zygoma. The condyle was removed by separating it from the zygoma along the joint space and drilling a series of holes through the neck, followed by section of the bone with a chisel. Into this defect, a piece of fascia lata from the right thigh was placed and the wound closed. The mouth could immediately be opened about 1 inch; this has increased with use so that at the present time an opening of 1⅜ inches is readily attained.

Pathologic Examination.—The specimen consists of the right mandibular condyle measuring 3 by 1.7 by 1.5 cm. Microscopic: The sections are composed of dense cortical and cancellous bone. At one point the bone is lined by a small fragment of hyaline cartilage. There is no evidence of inflammatory change. Pathologic Diagnosis: Bony overgrowth of mandibular condyle.

It is evident from the above case that not all bony overgrowths of the condyle are associated with the development of prognathism. Whether or not this occurs probably depends on whether the overgrowth takes place without destroying the joint cavity and limiting the motion of the jaws. It is a well-known clinical fact that ankylosis of the mandible is always associated with profound restriction of growth of the jaw.

Diagnosis.—The unilateral deformity and progressive change in occlusion of the teeth are the salient features of this condition. Involvement of the condyle is indicated by the pivotal motion of the jaw. Comparison of the midlines of the jaws with the mouth open and with the mouth closed indicates that the movement of the mandible is always in the direction of the involved condyle. This is a sign characteristic of any organic involvement of the mandibular joints producing a change in the condyle or in the joint cavity. There may be a cracking sound produced in the involved joint. The condition is usually painless.

It is evident that the diagnosis is not difficult. X-ray change in the mandibular condyle is strong confirmatory evidence of joint changes. Gruca and Meisels discuss the differential diagnosis and include leontiasis ossea, osteitis deformans, and acromegaly as the most likely possibilities.

It is interesting to note that Perthes and Borchers illustrate a case of leontiasis ossea affecting the mandible; the same case is included by Pichler in his monograph as osteoma affecting the mandibular condyle.

In our opinion there is little, if anything, to justify the inclusion of these conditions except that they may all involve the facial bones. The entire pathologic process seems to involve the condyle and neck of

the mandible only, with secondary changes analogous to warping in the other facial bones. These changes are probably associated with disturbed muscle pull on their various attachments. This was evident in our case by the difference in the position of the eyes and the obvious twisting of the mandible.

Treatment.—The therapeutic attack on this problem may be divided into two phases: (1) the reduction of the deformity, and (2) the restoration of occlusion of the teeth. The latter of these is the most difficult portion of the treatment. The external deformity may be reduced and the disease eradicated by excision of the involved condyle. This permits the jaw to be swung backward farther into the glenoid fossa reducing the facial asymmetry and bringing the teeth into a more normal alignment. In our case, however, due to the abnormal occlusion which had existed for several years, the teeth had moved sufficiently to prevent good interdigitation. Little attention has been given to the restoration of dental function in the previously reported cases. Gruca and Meisels and Oehlecker report they were able to restore occlusion by extracting several interfering teeth. Ivy states that, after excision of the condyles in his cases, normal occlusion was restored at once. In the case reported here, it was evident from the beginning that normal occlusion could not possibly be attained simply by an operation on the condyle, because of the deformity of both maxilla and mandible. However, it was felt that, in addition to improving the cosmetic appearance of the patient and stopping the progression of the deformity, the occlusion could be somewhat improved. In this task we had the assistance of Dr. S. F. Bradel, of the Zoller Dental Clinic of the University of Chicago. Following operation, the lower left posterior teeth were built into occlusion with silver crowns, which, when cemented in place, brought these teeth into articulation with the upper denture. At the present time, mastication is much more efficient than formerly, but it will probably be necessary to make several additional dental changes from time to time until a permanent occlusion is attained.

The interesting problem of epiphyseal arrest in cases of progressive prognathism associated with overgrowth of the mandibular condyle may be considered. We feel that these cases could advantageously be treated and the deformity decreased by early surgical attention to the involved condyle. It is evident from a study of these cases that the deformity tends to progress continuously and nothing is gained by waiting.

SUMMARY

A case of unilateral hypertrophy of the mandibular condyle associated with a chondroma is reported. The literature has been reviewed and forty-four cases reporting tumors or overgrowths of the condyle have been found. The diagnosis is made by the characteristic progressive

jaw changes associated with the development of malocclusion of the teeth. X-ray examination reveals an enlargement of the mandibular condyle. The etiology is unknown. Surgical removal of the involved condyle readily corrects the facial deformity, but the restoration of the occlusion of the teeth is difficult to attain.

REFERENCES

1. Brodie, A. G.: Differential Diagnosis of Joint Conditions in Orthodontia, Angle Orthodontist **4**: 160, 1934.
2. Dufourmentel, L.: Chirurgie de l'articulation temporo-maxillaire, Paris, 1929, Masson et Cie; Condylite hypertrophique du maxillaire inferieur, Bull. et mem. soc. chir. de Paris **20**: 886, 1928.
3. Eckert, Erich: Zur kenntnis der Osteome des Unterkiefers, Beitr. z. klin. Chir. **1**: 674, 1899.
4. Eiselsberg, F.: Ueber schiefen Biss in Folge Arthritis eines Unterkieferkopfchens, Arch. f. Chir. **79**: 589, 1906.
5. Gruca, A., and Meisels, E.: Asymmetry of the Mandible from Unilateral Hypertrophy, Ann. Surg. **83**: 755, 1926.
6. Hofer, Otto: Zwei Falle von schiefern Bisz Vierteljahrschrift für Zahnheilkunde **38**: 332, 1922.
7. Ivy, R. H.: Benign Bony Enlargement of the Condyloid Process of the Mandible, Ann. Surg. **85**: 27, 1927.
8. Oehlecker, F.: Progenie und Schiefer Bisz durch Osteom des einem Unterkiefergelenkfortsatzes, Beitr. z. klin. Chir. **163**: 177, 1926.
9. Perthes, G., and Borchers, E.: Verletzungen und Krankheiten der Kiefer, Stuttgart, 1932, Ferdinand Enke.
10. Pichler, H.: Handbuch der Zahnheilkunde. VI Band, Berlin, 1931, Urban and Schwartzenberg.
11. Sonntag, E., and Rosenthal, W.: Erkrankungen des Kiefergelenkes, Zentralbl. f. Chir. **61**: 1469, 1934.
12. Voelker, F.: Schiefer Biss durch Hyperostose des Unterkieferkopfchens, Verhandl. d. deutsch. Gesellsch. f. Chir. **1**: 147, 1907.

HEMATOGENOUS PYARTHROSIS DUE TO BACILLUS HAEMOPHILUS INFLUENZAE AND CORYNEBACTERIUM XEROSIS

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REGARDLESS of its questionable role in the etiology of influenza, *Bacillus haemophilus influenza* (Pfeiffer's bacillus) has long been known to produce pus and has been reported as the causative organism in a wide variety of suppurative processes, of which cerebrospinal meningitis is the most common. The following two cases of hematogenous pyarthrosis due to this organism are reported, not so much because of the rarity of the disease entity, but because of certain features not found in previous case reports.

CASE REPORTS

CASE 1.—An 8-months-old colored boy was admitted to the University of Kansas Hospitals Feb. 19, 1937. This child had been perfectly healthy until three weeks before admission, at which time he fell out of bed and the next day was very irritable and cried out when handled. The following day the right hip and left arm were apparently very tender and the patient's temperature was 102° F. The next day edema in the region of the right hip, left elbow, and wrist was noticed. The fever continued and on the third day following on the onset of edema the left wrist was incised and pus obtained. Roentgen pictures taken at this time of the hip, elbow, and wrist were negative for any bone or joint abnormality. Four days before admission the left elbow was incised and a large quantity of pus obtained. The temperature up to the time of admission ranged between 101° F. and 102° F.

The admission temperature was 102.4° F. The child appeared to be acutely ill. The right hip region was markedly swollen, and the right thigh was held in flexion and external rotation. The slightest motion at the hip produced severe pain. There was a draining sinus in the area of the left elbow and dorsum of the left wrist. There was moderate enlargement of these joints, but motion was almost complete and only slightly painful.

Laboratory examinations revealed 2,950,000 erythrocytes, 32 per cent hemoglobin, and 19,450 leucocytes.

The roentgenologist reported "no periosteal or bone change in the area of the right hip." However, there was "marked swelling of the soft tissues with complete dislocation of the head of the femur from the acetabulum." No abnormalities were noted in the roentgenogram of the left elbow, wrist, and chest.

After a preliminary blood transfusion, the right hip joint was incised on Feb. 20 and about one pint of thin yellow pus evacuated. The wound was packed open

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with petrolatum gauze, the dislocation reduced, and a plaster of Paris hip spica cast applied. The sinuses at elbow and wrist were explored and were found to connect with the respective joints.

The patient was fever free within one week after operation. Two blood transfusions were given during this period. On March 15 the cast was removed and on March 30 the child was dismissed with all wounds healed, complete and painless motion in the left elbow and wrist, and about 50 per cent of normal motion in the right hip. One month later complete motion had returned to the hip.

A bacteriologic study was made on three specimens of pus from the right hip joint. The first culture was taken at the time of operation, the second three days later, and the third fourteen days after the second. Each culture showed two organisms. One was a slender gram-negative bacillus which varied in length, produced a small, clear, nonhemolytic colony on blood agar, but did not grow on any media that was not enriched by blood in some form. Due to these characteristics, a diagnosis of *H. influenzae* was made. The second organism was a short, granular, deeply gram-positive bacillus, which morphologically and culturally resembled the corynebacteria or diphtheroid group.

Transfers from cultures of these two organisms were sent to the National Institute in Washington, D. C. Their report confirmed the diagnosis of *H. influenzae* and classified the gram-positive bacillus as *Corynebacterium xerosis.*

Three blood cultures were taken at weekly intervals. The first showed two organisms, a gram-positive and a gram-negative bacillus. This culture was destroyed by accident before complete studies could be made. The next two cultures were negative.

The pathogenic significance of *C. xerosis* is, of course, speculative. This organism is considered to be nonpathogenic and is found fairly frequently in either the normal or the diseased eye. A search of the meager literature on the subject did not reveal any instances of appearance in suppurative processes elsewhere. The presence of the bacillus in all three specimens of pus indicates that it was actually a factor in this case though it probably gained a foothold after the disease process had been started by the influenza bacillus. Further evidence of its active presence is found in the fact that it appeared in the direct smear of the last specimen of pus, though only gram-negative bacilli were seen in the two previous direct smears.

CASE 2.—A 59-year-old colored woman entered the University of Kansas Hospitals June 15, 1937, with the chief complaint of a painful and swollen right knee of ten days' duration. This patient was a known diabetic of twelve years' standing and had lost 100 pounds in weight (242 to 142 pounds) in the last year. This loss the patient attributed to hard work and diet and not to illness. She had had no respiratory infection or injury previous to the onset of pain in the knee.

The admission temperature was 101° F. The right knee was markedly swollen, the edema extending well into the thigh and calf. Motion was exceedingly painful. On aspiration, 100 c.c. of thin yellow pus was obtained.

Laboratory examinations revealed 3,840,000 erythrocytes, 50 per cent hemoglobin, 19,500 leucocytes, 363 mg. blood sugar, and Wassermann and Kahn tests negative.

The roentgenologist reported "no periosteal or bone pathology."

The knee was incised June 21, and a large amount of purulent material and debris was found. The capsule was very thick and inflamed. The joint was lavaged with warm saline solution and closed without drainage.

The patient was much more comfortable following operation. The wound broke down on the seventh day and drained for 8 weeks. The temperature returned to normal in 4 weeks.

On Aug. 7 this woman developed a cardiac condition diagnosed as coronary occlusion by the medical service. She was seriously ill for several weeks, but finally recovered sufficiently to be discharged from the Hospital Nov. 20. At this time the knee had been healed for weeks. There was about 60° of painless passive motion, but very little active motion due to general weakness.

Cultures of two specimens of pus from the knee joint were made. The first was obtained by aspiration and the second at operation. Each showed a pure culture of slender, gram-negative bacilli which varied in length. Cultural characteristics suggested an influenza bacillus and all attempts to grow the organism on media to which no blood had been added were unsuccessful. A transfer was sent to the National Institute in Washington, D. C., where the diagnosis of *H. influenzae* was confirmed. Short gram-negative bacilli were found in the direct smear. No blood cultures were taken.

DISCUSSION

In addition to the foregoing cases we have found reports of 22 others, a total of 24. If *C. xerosis* is accepted as a pathogenic factor, Case 1 might be excluded to make a total of 23, although we include this case in our tables as a matter of record. This series is readily divided into two groups; those associated with influenzal meningitis (Table I) and those

TABLE I

HEMATOGENOUS PYARTHROSIS DUE TO *B. Influenzae* ASSOCIATED WITH MENINGITIS

CASE	AUTHOR	AGE	PART INVOLVED	TREATMENT	RESULT
1	Bloise[1]	5 mo.	Ankle	Aspiration	Death in 6 days
2	Dahr[2]	Infant	Metacarpophalangeal joints	—	Death
3	Longo[3]	8 mo.	Knee and hip	—	Death
4	Lubinski[4]	6 mo.	Hip and wrist	—	Death
5	Nabarro and Stallman[5]	12 mo.	Knee	Incision and drainage	Death
6	Maya[6]	12 mo.	Shoulder	—	Death
7	Rivers[7]	4 mo.	Wrist	—	Death
8	Slawyk[8]	9 mo.	Wrist, ankle, and knee	—	Death
9	Volgelsang[9]	16 mo.	Knee and ankle, sternoclavicular joint?	—	Death
10	Von Gavel[10]	18 mo.	Knee	—	Death
11	Waaler[11]	20 mo.	Knee	—	Death

not so associated (Table II). Several case reports, at times listed as influenzal pyarthrosis, are not included in this series. These cases are listed in Table III. All but Cases 2 and 4 are undoubtedly instances of *H. influenzae* infection but for reasons, as indicated in the table, are excluded.

A study of Tables I and II indicates several points of contrast between the two groups. All cases associated with meningitis ended fatally,

TABLE II

HEMATOGENOUS PYARTHROSIS DUE TO *B. Influenzae* WITHOUT MENINGITIS

CASE	AUTHOR	AGE	PART INVOLVED	TREATMENT	RESULT
1	Burckhardt[12]	5 mo.	Elbow joint, soft tissue abscess of hip	Incision and drainage	Recovery with almost complete motion
2	Davis[13]	A few mo.	Shoulder	Aspiration	Improved
3	Fraser[14]	6 mo.	Shoulder	Incision and drainage	Recovery
4	Harris[15]	Child	—	—	Recovered
5	Harris[15]	Child	—	—	Recovered
6	Kubota[16]	14 mo.	Knee	Aspiration and injection of tripaflavin	Well in 1 mo.
7	Nabarro and Stallman[5]	23 mo.	Knee	Incision and drainage, Carrel-Dakin irrigation	Complete recovery
8	Nabarro and Stallman[5]	8 mo.	Knee	Incision, lavage of joint and closure	Healed P.P., complete recovery
9	Peterson[17]	7 mo.	Shoulder	Incision and drainage	Recovery, almost normal function
10	Taylor[18]	18 mo.	Knee	Repeated aspiration	Normal joint in 3 mo.
11	Taylor[18]	8 mo.	Knee	Incision and drainage	Joint healed, but patient died of erysipelas
12	Weaver and Sherwood	8 mo.	Hip, elbow, and wrist	Incision and drainage	Complete recovery
13	Weaver and Sherwood	59 yr.	Knee	Incision, lavage, and closure	Subsequent drainage with healing; passive motion good, active motion nil due to debilitation from other disease

while those not so complicated recovered with excellent function of the joint or joints involved regardless of the type of local treatment. There was only one death in the latter type and this was said to be due to erysipelas and at autopsy a healed joint was demonstrated. Multiple joint involvement is frequent in the meningitis type, while the opposite is true of those cases not associated with meningitis.

The most striking point of similarity noted in all three tables is the age of the patients, the oldest recorded being 23 months, with the exception of our Case 2 which was a 59-year-old woman. As far as can be learned, this is the first instance of occurrence in an adult to be reported. Lemierre, Meyer, and Laplane[27] report a 49-year-old woman with bronchopneumonia, large ulceration of the nasopharynx, bullous lesion of the back of the neck, and arthritis of the shoulder and sternoclavicular joint. Influenza bacilli were isolated from the blood, ulcer, and bullous lesion. There was apparently no fluid in the affected joints and the edema disappeared with the recovery of the other lesions. This arthritis

TABLE III

CASES SOMETIMES CITED AS PYARTHROSIS DUE TO *B. Influenzae* BUT NOT INCLUDED IN THIS SERIES

CASE	AUTHOR	AGE	COMMENT
1	Dudgeon and Adams[19]	10 mo.	Apparently osteomyelitis of radius and femur with extension into elbow and hip joints, meningitis and death
2	Frindt[20]	21 yr.	Evident myelitis which occurred several weeks after attack of influenza; no joint symptoms whatsoever; no bacteriology done; no reason to believe *B. influenzae* at fault; recovery
3	Kristensen and Christensen[21]	18 mo.	Apparently subcutaneous abscess at external malleolus of ankle.
4	Ochsenius[22]	2 yr.	Suppurative arthritis of hip considerable period after "grippe"; no bacteriology
5	Pacchioni[23]	12 mo.	Same case as Maya[6]
6	Shaw[24]	12 mo.	Probable osteomyelitis of lower end of femur with extension into knee joint; recovery; no note on function
7	Sorrell, Jung, and Greiner[25]	12 mo.	Apparent osteomyelitis lower end of humerus with extension into elbow joint
8	Taylor[18]	7 mo.	Possible osteomyelitis of head of femur.
9	Wollstein[26]	8 mo.	Osteomyelitis lower end of humerus; meningitis and death

was no doubt a toxic manifestation, a phenomenon noted not infrequently in other case reports, but not included in our series.

The mode of entrance of the organism into the blood stream is not clear. As a rule no history of influenza or upper respiratory disease was elicited preceding the joint symptoms. In cases of meningitis the joint infection may precede, follow, or occur simultaneously with meningitis.

CONCLUSIONS

Hematogenous pyarthrosis due to the influenza bacillus usually occurs in infants. It rarely occurs in adults. If not associated with influenzal meningitis, the prognosis as to life and function of the joint is excellent, but if so associated the end result is death.

REFERENCES

1. Bloise, N. L.: Meningitis Aguda y arthritis por bacilos de Pfeiffer en um lactanfe de tres meses, Arch. de pediat. d. Uruguay **4**: 99, 1933.
2. Dahr, P.: Influenzabakterien Meningitis und Influenzabakterien Sepsis mit Gelenk Metastase, Deutsche med. Wchnschr. **60**: 782, 1934.
3. Longo, A.: Sopra un caso di poliartrite e meningite purulenta da bacterio emofilo, Policlinico sez. med. **14**: 130-140, 1907.
4. Lubinski, H.: Influenzabazillen als Eitererreger, Centralbl. f. Bakt. **91**: 464, 1924.
5. Nabarro, D., and Stallman, J. F. H.: On Influenzal Arthritis, Lancet **2**: 743, 1924.
6. Maya, G.: Meningitis Cerebro-spinale fibrino-purulenta da bacillo di Pfeiffer, Gaz. Degli Ospedali E. Della Clin. **24**: 268, 1903.
7. Rivers, T. M.: Influenzal Meningitis, Am. J. Dis. Child. **24**: 102, 1922.
8. Slawyk, P.: Ztschr. f. Hyg. u. Infectionskrankh. **32**: 443, 1899.
9. Volgelsang, T. M.: Et tilfoelde av pyaemia med meningitis og pyarthros fremkaldt av Pfeiffers bacille, Med. rev. Bergen. **44**: 207, 1927.
10. Von Gavel, R.: Ein Fall von Influenza-meningitis und Influenzasepsis mit eitriger Gonitis durch Influenzabazillen, Arch. f. Kinderh. **79**: 161, 1926.

11. Waaler, E.: To tilfelle av purulent infeksjon med B. Influenzae Pfeiffer, Norsk mag. f. laegevidsk. **92**: 715, 1931.
12. Burckhardt, J. L.: Influenzaartige Stäbchen Als Eitererreger, Kor. bl. Schweig. **49**: 1381, 1919.
13. Davis, D. J.: Infections With Hemoglobinophilic Bacteria, J. A. M. A. **64**: 814, 1915.
14. Fraser, Eliz. T.: Suppurative Arthritis of Knee Joint Due to Influenza Bacillus, Lancet **1**: 1573, 1911.
15. Harris, M. B.: Acute Suppurative Arthritis in Children, J. Bone & Joint Surg. **23**: 849, 1925.
16. Kubota, I.: Sur un Cas. D'Arthrite Purulente Causee Par le Bacille Influenza Chez L'enfant, Orient. J. Dis. Infants **6**: 24, 1929.
17. Peterson, J. C.: Suppurative Arthritis Due to Hemophilus Influenzae, J. Pediat. **7**: 765, 1935.
18. Taylor, J. F.: Suppurative Arthritis Due to Haemophilic Bacteria, Lancet **1**: 1341, 1927.
19. Dudgeon, L. S., and Adams, J. E.: A Case of Pyemia Due to the Influenza Bacillus With Multiple Arthritis and Meningitis, Lancet **2**: 684, 1907.
20. Frindt, F. J.: Az influenza ritka Szovodmenye, Budapesti orvosi ujság **32**: 322, 1934.
21. Kristensen, M., and Christensen S.: Six nouveaux cas de meningite a bacille de Pfeiffer, Acta med. Scandinav. **60**: 1, 1924.
22. Ochsenius, K.: Koxitis Mit Spontanluxation bei Grippe, Deutsche med. Wchnschr. **48**: 1726, 1922.
23. Pacchioni, D.: Aleuni case de sierositi purulente determinate dal B. di Pfeiffer, Scritti Medici in Anore di C. Bozzolo, Torino 397, 1904.
24. Shaw, F. W.: Suppurative Arthritis Due to Hemophilic Bacteria, Virginia M. Monthly **57**: 404, 1930.
25. Sorrell, E., Jung, A., and Greiner, G.: Arthrite du Coude a Bacilles de Pfeiffer Simulante une Arthrite Tuberculeuse, Rev. d'orthop. **41**: 125, 1934.
26. Wollstein, Martha: Influenzal Meningitis and Its Experimental Production, Am. J. Dis. Child. **1**: 43, 1911.
27. Lemierre, A., Meyer, A., and Laplane, R.: Les septicemies à bacille de Pfeiffer, Ann. de méd. **39**: 97, 1936.

A SIMPLE OPERATION FOR THE DISCHARGING NIPPLE

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THE repeated discharge of droplets of liquid from the nipple of a nonlactating breast usually arouses the fear of a cancer in the woman affected. While occurring at any age, it commonly appears after the menopause and the cause is a benign adenopapilloma occupy-

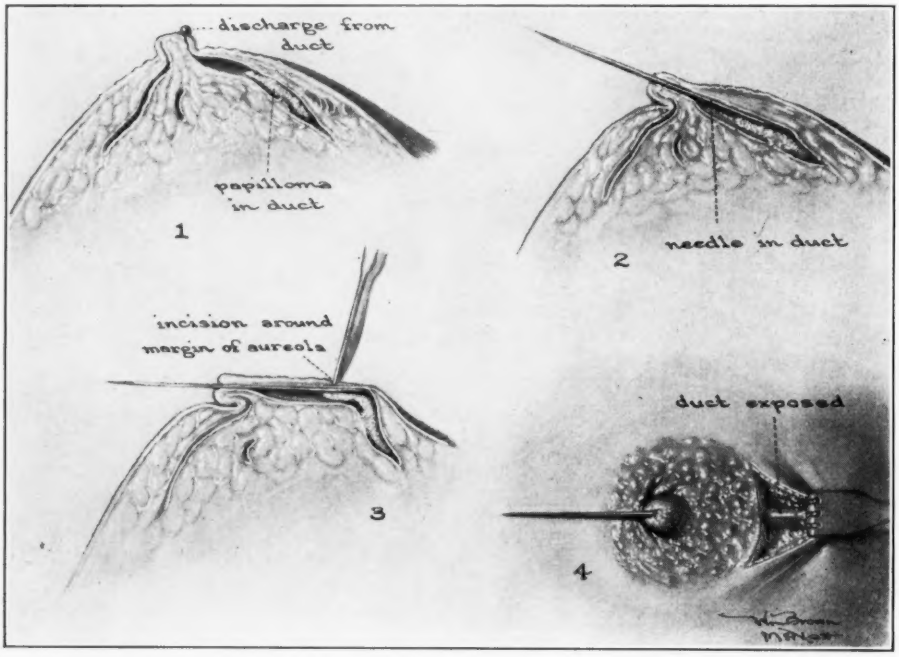

Fig. 1.—Excision of papilloma containing mammary duct. *1*, The orifice of the involved duct is located by the exuding mucoid or bloody droplet. *2*, The duct is dilated by the introduction of the blunt ends of ordinary sewing needles of increasing size. *3*, An incision along the areolar border is made centering over the affected duct. *4*, By tilting the outer end of the needle, the duct is raised and demonstrated in the wound.

ing one of the larger lactiferous ducts lying under the areola. The discharge is viscid or mucoid, turbid or grayish in color, and, in drying upon the clothing, it stiffens the fabric and leaves a yellowish spot on the garment. Often the droplets resemble pure blood and result from the necrosis or breaking of the delicate papillary filaments which occupy the duct. On gentle palpation over the areola, a compressible, rounded mass may be detected, pressure upon which is followed by the escape of the droplets from a single point on the nipple.

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As a rule, when the dilated part of the duct is thus emptied by pressure, the little mass disappears to palpation, to again become perceptible when it fills. Occasionally a poorly circumscribed area of induration remains after the duct has apparently been emptied. Such a residual thickening suggests a duct carcinoma, and promptly should be subjected to biopsy. It has been said that 50 per cent of intraductal papillomas cause the bloody discharge and that in 30 per cent

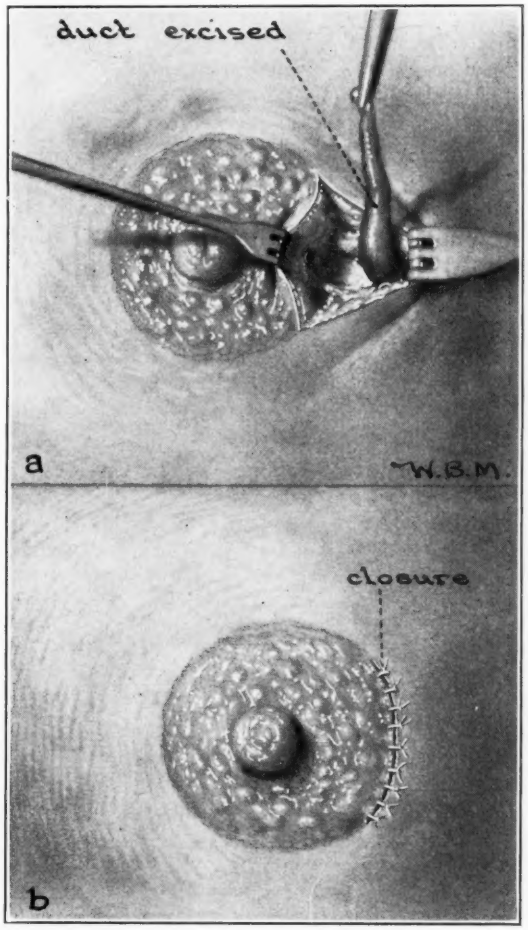

Fig. 2.—*a*, The papillomatous portion of the dilated duct is freely excised without ligation; and *b*, the incision along the areolar border is accurately united with fine dermal sutures.

of these malignancy is present. In my personal experience hardly 10 per cent of abnormal discharges from the nipple are due to cancer and the malodorous watery discharge from the nonulcerated nipple which has been described as especially indicative of carcinoma I do not recall having seen. In advanced scirrhus of the breast a very thin dry scale or crust upon the nipple is not uncommon, but this is very different from the droplets of liquid from an intraductal papilloma. While, therefore, the abnormal discharge usually is not ominous and although

patients with carcinoma of the breast rarely give a history of a preceding bloody or mucoid discharge from the nipple, for duct carcinoma is not common, obviously it is very desirable that all duct papilloma be removed. This, however, has not always been easy. Under pressure of the knife, the duct empties and is then difficult to locate in the wound. By putting a ligature or rubber band about the base of the nipple, we have tried to maintain a distended duct but too often the ligature fails to hold or in its application the duct is emptied. Eccles suggested that the nipple be split in half but we have seen the surgeon unable to find the dilated segment of duct after carefully splitting the nipple. By the following simple procedure and without disfigurement, the papillomatous duct may positively be identified and removed. It is essential that the patient come to the operation without any manipulation of the breast that might empty the duct. Therefore, the skin of the breast is sprayed or painted with the sterilizing solution without pressure. Supplied with a sterile set of the ordinary housewife's sewing needles ranging in size from a fine cambric to a small long darning needle, the operator locates the orifice of the dilated duct by gently expressing a minute droplet of the liquid. The blunt or eye end of an appropriately fine needle is introduced into this duct, followed by needles of larger size. The minute orifice readily dilates and then becomes easy to distinguish from the other orifices on the nipple. Finally the long slender darning needle is introduced to or beyond the edge of the areola. An incision exactly along the areolar border, centering over the needle, is made and (Fig. 1) the edges of the wound are retracted. Clamping the outer pointed end of the needle in an artery forceps, the duct is tilted into the wound. Here it is readily freed from surrounding tissue and the diseased portion excised. The contained papilloma is soft and often quite elongated and may extend 5 to 20 mm. or more along the duct. The ends of the resected duct are not ligated. Ligatures, if required for bleeding points, should be of very fine silk or of 000 plain catgut. For the skin we prefer interrupted sutures of 35 or 36 gauge annealed rustless steel wire tied in a square knot. This little operation, which may be done under local or gas-oxygen anesthesia, does not necessitate confinement to bed and there should be little appreciable reaction in the wound. As erectile tissues are involved, it is wise to leave two or three of the sutures in place for eight to ten days. The needles costing but a few cents suffice, but the surgeon who hesitates to exhibit such plebeian instruments, may have his name affixed to a set of fine, fairly rigid probes of rustless steel or iridium-platinum, with special delicate handles. I have experimented with simple dilatation of the duct and the injection of sclerosing solutions, and, while the bloody discharge may cease, such procedures are not recommended.

CYSTIC DISEASE OF THE LUNG

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CYSTIC disease of the lung is a rare pathologic condition which offers many diagnostic and etiologic problems. Schenck has collected 381 cases from its first description by Malpighi in 1687 up to July, 1937, to which we can add the cases of Churchill, Romhanyi, Gale, Wood, and Chodkowska which have been published during the past year. Approximately 60 of these cases have appeared in the American literature since Pappenheimer's first description of a case in 1912. Many of the case reports refer only to the clinical symptoms, especially the roentgenologic findings, and only a relatively small number of cases have been studied from a pathologic point of view. A recent and very complete paper on this subject has been published by Romhanyi and Maccone, who report the case of a 16-year-old boy suffering with severe dyspnea for one year and dying during a severe attack of cyanosis with a spontaneous right-sided pneumothorax. In the discussion of the case the authors emphasize the difficulty of determining the pathogenesis of cystic lungs in adults. Serial microscopic sections showed, in their case, communications between the cysts and the terminal bronchioles which without widening pass directly into a normal alveolus. Because of the previous history of measles and upper respiratory infection, the authors regarded this lesion as an acquired condition characterized by a dilatation of the respiratory bronchioles in the peripheral branches. There was no evidence of any developmental anomalies. Anthracotic pigment was present in the walls of the cysts, and there was a dense lymphocytic infiltration in the cystic areas.

Pierce and Dirkse consider true congenital cysts in adults to be very rare and believe that the assumption of the "congenital" nature was mostly founded upon insufficient evidence partly due to a lack of a satisfactory antecedent history, or due to an insufficient evaluation of intercurrent or antecedent respiratory diseases by the physician.

According to Hart, the age of the patient should be important in the consideration of the etiology of this lesion since he believes that the congenital cysts are confined to the newborn only.

In contrast to these authors, Wolman, Koontz, Miller, Grawitz, and others consider the great majority of cystic conditions of the lung as a congenital anomaly regardless of the age and antecedent history of the patient.

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Among 6,000 autopsies performed by the Department of Pathology of Ohio State University in the past, only two cases of cystic disease of the lung were observed. They presented such a different gross pathologic condition that the possibility of a different etiology in each case presented itself. Because of the hazy concept concerning the pathogenesis of cystic lung disease in the adult, we wish to report them briefly.

CASE 1.—A 51-year-old white male who had been a glass blower for the past sixteen years entered the hospital complaining of dyspnea and hemoptysis. One year prior to admission the patient had suffered a severe cold which confined him to bed for ten days. Thereafter he developed a productive cough which was frequent and paroxysmal in character. The dyspnea which was present sometime before his acute illness increased markedly, and the sputum was occasionally blood-streaked. His past history and his family history were of no importance. The physical examination of his chest showed an increase in bronchophony and pectoriloquy over the right apex with moderately diminished breath sounds over the remainder of the lung. The physical examination was otherwise negative. In repeated examination of his sputum acid-fast bacilli were found once; otherwise the sputum was that of a chronic purulent bronchitis. Examination of his urine and blood showed no deviation from the normal. Serologic tests for syphilis were negative. X-ray examination of the chest showed pleural adhesions present in both lungs. There was evidence of marked cloudiness in the apices with evidence of cavities in both sides. There was also evidence of perihilar fibrosis. The roentgenologic diagnosis was that of a chronic fibroid tuberculosis. During his stay in the hospital, the amount of sputum decreased from 80 c.c. to approximately 20 c.c. daily. Attempts at an artificial pneumothorax had to be discontinued because of pleural adhesions. Throughout the year the sputum examination remained negative for acid-fast bacilli. There was never an increase in temperature, and the patient gained weight. In his fourteenth hospital month the patient developed a coryza with rather severe irritating cough. He became suddenly dyspneic and severely cyanotic and died suddenly.

The autopsy showed a well-developed, well-nourished white male adult. There was no evidence of any developmental anomalies. Upon opening the thorax, dense pleural adhesions were found in both pleural cavities which fixed both lungs firmly to the chest wall. The heart was markedly enlarged, weighed about 600 gm., and showed an enormous dilatation of the right auricle and ventricle. The valves of the heart were intact. Both lungs showed essentially a similar picture. The upper lobes of both lungs had a shrunken appearance and consisted of firm and fibrous lung tissue in which innumerable small cystlike cavities were found. These cavities ranged in size from 3 mm. to 3 cm. in diameter and were lined by a pale, smooth, and glistening membrane. A few of the cavities contained a small amount of yellow purulent mucoid material. There was no evidence of caseation or tubercle formation. The cystic cavities communicated with the larger bronchi, the walls of which were frequently thickened and corrugated. This process extended over both upper lobes and the middle lobe of the right lung. The lower lobes were enlarged and crepitant, and the alveoli were distinctly increased in size. There was a moderate amount of edema in the dependent parts of the lungs. The bronchi leading to the lower lobes showed a pale, smooth, and glistening mucosa. The peribronchial lymph nodes were moderately enlarged and showed a considerable amount of anthracotic pigment. The other organs of the body showed no pathologic changes except a moderate passive congestion.

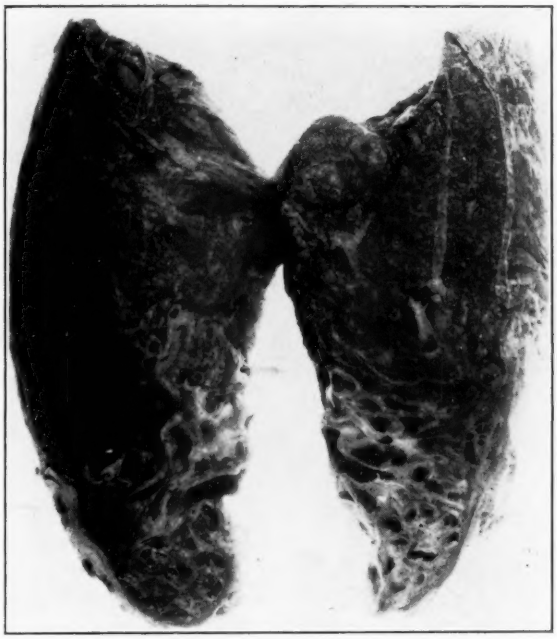

Fig. 1.—Case 1. Cyst formation with bronchiectasis and pulmonary fibrosis in both upper lobes.

Fig. 2.—Wall of large cyst lined with high columnar partly ciliated epithelium (hematoxylin and eosin, ×120).

Fig. 3.—Cyst wall lined with vascular granulation tissue (hematoxylin-eosin, ×120).

Fig. 4.—Proliferations of alveolar epithelium in fibrosed parts of the lung (hematoxylin and eosin, ×120).

Histologic examination of the upper lobes of the lungs showed cystic spaces lined, in the majority of cases, with a high columnar epithelium which in some areas gave the impression of being ciliated. In other areas the epithelium had disappeared and was replaced by a very vascular nonspecific granulation tissue. With the van Gieson stain strands of fibrous tissue interspersed with numerous capillaries and infiltrated by inflammatory cells of the myeloid and lymphocytic groups could be demonstrated beneath the epithelial layer. There was remarkable scarcity of smooth muscle fibers. Sparse anthracotic pigment could be noted in the fibrous wall of the cyst. In the wall of the larger cystic spaces remnants of cartilaginous tissue were found. With the elastica stain of Weigert the presence of rudimentary elastic

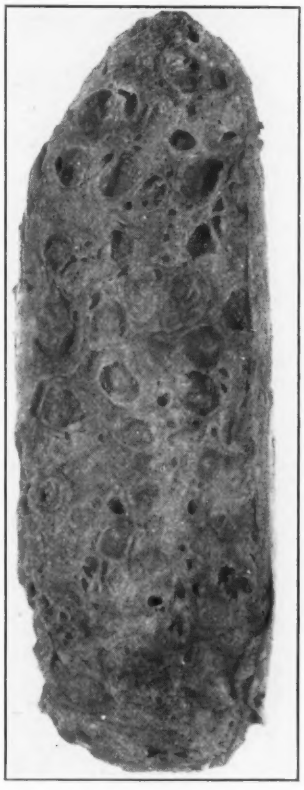

Fig. 5.—Case 2. Small cysts surrounded by compressed emphysematous lung tissue in the upper and middle lobes of the right lung.

fibers beneath the epithelium could be demonstrated. In areas of pyogenic granulation tissue elastic fibers were completely absent. The tissue between the cystic spaces consisted largely of a dense fibrous tissue containing dilated and engorged blood vessels and numerous foci of lymphocytic infiltration. Between the bundles of fibrous tissue, small slitlike spaces could be observed with a cubical epithelium resembling proliferated alveolar epithelium. In some sections plasmodium-like agglomerations of epithelium were found resembling multinucleated cells. No histologic evidence of tuberculosis was present in the sections examined. With a Gram stain a large number of bacteria was observed in some of the cystic cavities and in the pyogenic granulation tissue. Among these large yeast colonies were especially conspicuous, having often penetrated deep into the fibrous tissue.

CASE 2.—A 28-year-old white male, who had been a punch press operator for the past two years, was admitted to the hospital with a history of a long-standing cough. This cough had been present as long as the patient could remember, but had increased in the past two months and had become associated with dyspnea and slight cyanosis. The patient had lost considerable weight during the last three months, and his sputum had shown an occasional streaking with blood for the last six months. For his persistent cough the patient was admitted to the hospital. His past history showed that the patient had had measles and influenza in early childhood, from which time his mother traced the onset of his cough. Otherwise the patient had been in good health.

The physical examination revealed a well-developed, poorly nourished white male who was dyspneic on exertion and showed moderate cyanosis of his mucous mem-

Fig. 6.—Cysts lined with ciliated columnar epithelium, filled with mucus (hematoxylin and eosin, ×120).

branes. There was dullness to percussion over his entire right chest with slightly increased tactile fremitus and coarse bubbling râles over the entire right lung. Percussion was resonant over the left lung fields, and the breath sounds were diminished. The heart was within normal limits, and there were no adventitious sounds. There were no other remarkable physical findings. On admission his red blood count was 5,500,000; his white blood count, 13,000. The serologic examination of his blood was negative for syphilis. X-ray examination of the chest showed a general fibrosis of both lungs. The right upper and middle lobes showed a number of moderate sized circular areas of decreased density suggesting a cystic condition. His vital capacity was slightly reduced. There was no fever. The sputum of the patient amounted to 500 to 750 c.c. per day. It was thick and yellow, rich in mucus, and no tubercle bacilli were found at any time. Occasionally it was streaked with blood.

Fig. 7.—Massive irregular bundles of elastic fibers in cyst wall (Weigert's elastica stain, ×120).

Fig. 8.—Monilia organisms in the wall of the cyst (Gram stain, ×360).

The patient stayed in the hospital for five months and left without improvement. Twenty months later the patient was readmitted. His condition had remained much the same, but his cough and the hemoptysis had increased. The physical examination showed identical findings over the lungs, but a slight increase in the size of the heart. The x-ray examination showed a definite increase of the pathologic findings over the right lung with a marked emphysema of the entire left lung. Although no lipiodol was injected, the presence of multiple small cysts throughout the lung fields, the persistent absence of tubercle bacilli, and the presence of the persistent cough with copious sputum suggested the clinical diagnosis of cystic disease of the lung. His weakened condition did not permit his discharge, and he was kept in the hospital with the hope of getting him in condition for surgical intervention. During his second stay in the hospital, he became rapidly more dyspneic, cyanotic, and weaker. The patient died with symptoms of cardiac failure three months after his second admission.

The autopsy showed the body of a well-developed, emaciated white male adult. Externally there was nothing remarkable. The peritoneal surfaces were smooth and glistening, and no abnormalities were observed. The chest plate was removed in the usual manner and was found adherent to the anterior surface of the right lung. The right pleural cavity was obliterated by fibrous adhesions. The left lung was found free within the pleural cavity and covered with a moderate amount of fibrinous exudate. The pericardium contained a few cubic centimeters of yellow clear fluid. The heart showed a moderate hypertrophy and dilatation of both ventricles. The endocardium and the myocardium seemed normal. The right lung was approximately normal in size. Its surface was covered with dense fibrous adhesions. The lung was crepitant throughout and variable in its consistency. The cut surface revealed a large number of cysts which varied in size from 5 mm. to 2 cm. with an average diameter of 1.5 cm. The cysts were empty and lined with a smooth glistening membrane. The large bronchi showed moderate dilatation with marked thickening of their walls. Their lumens contained a considerable amount of thick purulent exudate. The small amount of lung tissue found between the cysts seemed compressed and without elasticity, but showed no gross pathologic changes. The left lung was approximately normal in size. Its surface was smooth except for the presence of a small amount of fibrinous exudate. The upper lobe was crepitant, while the lower lobe showed scattered confluent areas of grayish consolidation. On section the large bronchi showed marked dilatation with thickening of walls. Most of them were filled with mucopurulent material. Only a few small cysts, averaging 5 mm. in diameter, were found scattered throughout the lung. The areas of consolidation in the lower lobe were patchy in distribution and showed a granular reddish-gray dry surface. The other organs of the body showed no further gross pathologic conditions except a moderate chronic passive congestion.

Histologic examination of the right lung showed the cysts to be lined with high columnar epithelium resting usually upon a small strip of a very vascular and loose fibrous tissue with marked round cell infiltration. Even in the smaller cysts the epithelial lining was of high columnar cell type. In the larger cysts the epithelial layer was sometimes entirely missing, their walls being formed by the vascular granulation tissue alone. The alveoli adjoining these cysts appeared compressed while others were emphysematous. In some areas the space between these cysts was filled with fibrous tissue in which strands of proliferated alveolar epithelium could be noted. These seemed occasionally to form dilated alveoli resembling small cysts. With the van Gieson stain a marked fibrosis of the lung tissue between the cysts could be demonstrated. The wall of the cyst itself was formed principally by loose connective tissue with numerous blood capillaries. Only few smooth muscle fibers could be demonstrated. The elastica stain

revealed a varying amount of elastic fibers in the wall of the cyst. In most instances no distinct elastic layer could be distinguished, but loosely and disorderly arranged elastic fibers were seen frequently within the fibrous tissue. Rarely were elastic fibers completely absent in the wall of the larger cysts. With a Gram stain a severe infestation of cyst walls and fibrous areas of the lung with Monilia-like organisms could be found.

DISCUSSION

Cystic disease of the lung, also known under such terms as cystic degeneration of the lung, honeycomb lung, fetal bronchiectasis, and cystic fetal bronchial adenoma (Oechsli and Miles), is only an ill-defined clinical entity. It may occur in all stages of life, although most cases appear in infancy and young adulthood. Large cysts usually will cause the death of the fetus in utero, infancy, or early life, while the average age attained in the presence of small cysts is 55 years (Stewart, Kennedy, and James). Extremely few observations have been made in the negroid races, and the relatively small number of cases published in the American literature does not permit making conclusive comparisons. The occupation seems to play no part in the incidence, although our first patient was a glass blower, an industry in which respiratory and bronchial diseases are especially common (Hope).

The clinical symptoms vary markedly and depend largely upon the size and location of the cysts, their communication with the bronchi, and the presence of infection. A cough traceable to early infancy with attacks of dyspnea and cyanosis, such as present in our second case, may be considered the most typical symptoms suggestive of the disease. According to Miller, repeated attacks of spontaneous pneumothorax may also suggest such a diagnosis. The value of an active infection, pneumonia, or measles in the past history as a cause of saccular dilatation of the bronchi is considered insignificant by Eloesser, in contrast to the opinion of Romhanyi and Maccone. Very often, however, no symptoms of the condition may be present until an intercurrent infection takes place, as in our first case and in the case of Oechsli and Miles.

The physical findings present in extensive cystic degeneration of the lung depend upon the size and contents of the cysts and upon the condition of the lung tissue between the cystic cavities. Râles are frequently present in all stages but not constantly. The importance of x-ray examination for the diagnosis is justly emphasized by Oechsli and Miles. Stereoroentgenograms and the injection of lipiodol (Eloesser) are undoubtedly of great help in the hands of the diagnostician. The x-ray examination was responsible for the clinical diagnosis made in our second case. To differentiate between congenital and acquired cysts of the lung during the life of the patient is extremely difficult (Romhanyi and Maccone) and of little importance. Morlock and Pinchin suggest as clinical tests of differentiation the absence of pleural adhesions over the cystic areas as proved by the ability to produce com-

plete pneumothorax, and the absence of pigment on the pleural surface covering the cysts as observed with the thoracoscope in the congenital type.

The gross pathologic lesions as revealed at autopsy are usually sufficiently characteristic to permit a pathologic diagnosis. The important gross anatomical feature is the presence of numerous cysts lined by smooth, glistening membranes and surrounded by normal lung tissue (Sauerbruch), as it was classically exemplified in our second case. Long-lasting infection may destroy this picture. The cyst may then resemble an abscess and the lung tissue between the cysts may be replaced by fibrous tissue as in our first observation. The presence of mucoid or colloid material in the cysts, which Smith considers as a proof of an active secretion from the cyst wall, should not influence the gross pathologic diagnosis, while in the presence of caseous masses tuberculosis must be excluded first (Pascual and Ballester). The number of cysts and their distribution over the lung may vary a great deal. In the 374 cases of Schenck, 141 showed solitary cysts; 233, multiple cysts; 21 per cent of the cases had bilateral involvement, while in 42 per cent the right lung was involved only, and in 37 per cent the left lung. There may or may not be a demonstrable connection with the bronchial tree (Stewart, Kennedy, and James), and, according to DaCosta, the latter always shows a more or less severe degree of dilatation. In the case of Grawitz, as in our second case, each small cyst was complete in itself with no communication with the bronchus. Stewart, Kennedy, and James could show with careful reconstruction of the cysts in the wax model that the majority of the cysts communicated with the bronchial tree and that only a small number proved to be "true cysts." The final pathologic diagnosis of this condition depends upon the histopathologic examination of the cystic spaces in the lung (Frates). In most of the cases an epithelial lining can be distinguished which shows all varieties from the high columnar ciliated type to a flattened or cuboidal epithelium (Collins). In our second case all these transitions could be well demonstrated in the cysts of various sizes. In the case of Blatt and Jacobs some of the cysts showed a thick lining with squamous epithelium, which must be considered as an expression of metaplasia. If the epithelial lining is absent, vascular granulation tissue is observed (Robertson), suggesting the presence of an infectious process. In our second case this granulation tissue often formed small papillae, giving the cyst wall a finely granular appearance. The wall of the cyst lined with intact epithelium usually shows structures commonly seen in the wall of bronchi or bronchioles (Parmelee and Apfelbach). In both our cases islands of cartilaginous tissue, fibrous tissue, and an abundant amount of elastic tissue could be found irregularly distributed in the walls of the large or smaller cysts. Smooth muscle fibers were scarce,

in contrast to the observation of Frates. Glandular formations resembling bronchial mucous glands were found frequently in the walls of the larger cysts. The lung tissue between these cystic spaces may assume a varying picture. Koontz describes the presence of large emphysematous blebs between these epithelial lined cysts, and Nelson also considers a dilatation of the alveolar spaces between the cysts as typical. This picture was represented in our second case, while our first case showed marked fibrosis with evidence of inflammation between the cystic spaces. Remnants of alveoli lined with low cuboidal epithelium were found interspersed between the strands of fibrous tissue, similar to the observation of Wolman. In these some plasmodium-like structures are often found (Chodkowska), and there seems no doubt that these pictures are similar to the alveolar proliferation described by Oudendal and represent an actual proliferation of alveolar epithelium. The presence of these cuboidal cells seems to signify to Robertson that those alveoli are not functioning, and they usually appear compressed and contain little air. Only occasionally small cysts lined with similar cuboidal epithelium are found resembling the dilated hypertrophic alveolar spaces as described in the case of Wolman. Evidence of an inflammatory process is always present but varies greatly in its extent. It consists usually of areas of round cell infiltration which are found in the granulation tissue forming the wall of large infected cysts. This was especially prominent in our first case. In neither of our cases was histologic evidence of tuberculosis present, although a tuberculous infection of lung cysts may well occur. An accumulation of eosinophiles in the cyst wall has been described by Pappenheimer. The inflammatory changes can be explained by the extensive infection present in some of the cysts, which could be easily demonstrated by us with the Gram stain. Here especially the presence of large colonies of monilia in both cases seems significant. The monilia organism was usually found in the granulation tissue of the large cyst walls, but also penetrated deeply into the fibrous septa between the cysts.

The etiology of cystic lung disease has been much discussed, and two points of view are in sharp contrast: those who believe that the majority of the cases are congenital in origin (Sauerbruch, Grawitz, Pascual and Ballester, Schenck, and others) and those who see it as an acquired condition (Romhanyi and Maccone and Pierce and Dirkse). The congenital origin of the majority of the cysts is deduced from the presence of other malformations in the same organism, its occurrence in the stillborn, the large volume of the unaffected lung, the frequent absence of adhesions over the cystic areas, and the lack of pigment in the cystic spaces (Grawitz). Some of the arguments against the predominantly congenital nature of cystic disease in the adult are: the long symptomless interval which often extends well

into middle age, the frequent occurrence of respiratory diseases or measles in the antecedent history, and the severe infection of the bronchial tree with bronchiectasis, which is usually found when the patient comes to autopsy. It is beyond the scope of this paper to discuss in detail all the arguments in favor of the respective theories, and we wish to stress only a few points which can be gained from the comparison of our two observations. Our second case presents all the earmarks of a typical case of congenital cystic disease of the lung due to the history, the gross pathologic findings, and the histologic appearance of the cysts. In our first patient the presence of an acquired condition may be considered. In its favor we may mention his age and occupation, the fact that the disease was comparatively short in duration, and the severe bronchiectasis and infection which accompanied his cystic condition. A histologic comparison of both cases, however, fails to show any remarkable difference in the microscopic appearance of the cysts except that the inflammatory changes are by far more extensive in the first case than in the second. In both instances the cystic structures, as far as they are not destroyed by inflammatory processes, resemble dilated bronchi or bronchioles with the identical atypical composition of their wall. From both cases we gain the impression that the condition is a progressive one as the epithelium showed all signs of active proliferation.

SUMMARY

Two cases of cystic disease of the lung in the adult are presented. In the first case, a 51-year-old glass blower, the lesion involved the upper lobes of both lungs and was associated with severe bronchiectasis and pulmonary fibrosis. In the second case, a 28-year-old punch press operator, the lesion was scattered over the upper and middle lobes of the right lung with normal or emphysematous lung tissue present between the cysts. Although the history of the patient, the clinical course of the disease, and the gross pathologic appearance of the lesions showed remarkable differences, suggesting a different etiology in each case, the microscopic appearance of the cysts was identical except for a varying degree of inflammation and infection. Both cases seemed to represent progressive lesions at the time of the autopsy.

REFERENCES

1. Ballon, H. C., Singer, J. J., and Graham, E. A.: Surgical Diseases of the Chest, Philadelphia, 1935, Lea & Febiger, p. 577.
2. Blatt, M. L., and Jacobs, H. M.: Solitary Congenital Air Cyst of the Lung, Arch. Pediat. **52**: 250-258, 1935.
3. Chodkowska, S.: Kasuistische Beiträge zur Kenntnis der Wabenlunge, Virchows Arch. f. path. Anat. **301**: 746-751, 1938.
4. Churchill, E. D.: Lobectomy and Pneumonectomy in Bronchiectasis and Cystic Disease, J. Thoracic Surg. **6**: 286-311, 1937.
5. Collins, D. H.: Congenital Cystic Disease of the Lungs Associated With a Giant-Cell Hyperplasia of the Lymph Glands, J. Path. & Bact. **37**: 123-125, 1933.

6. DaCosta, J. C.: Modern Surgery, ed. 10, Philadelphia, 1933, W. B. Saunders & Co., p. 826.
7. Eloesser, L.: Congenital Cystic Disease of the Lung, Surg., Gynec. & Obst. **52**: 747-758, 1931.
8. Frates, A.: Sul polmone policistico bronchiettasico congenito, Clin. med. ital. **67**: 266-288, 1936.
9. Gale, J. W., Keeley, J. L., and Coon, H. M.: Total Pneumonectomy for Congenital Cystic Disease of the Lung, J. Thoracic Surg. **6**: 626-633, 1937.
10. Von Grawitz, P.: Ueber Angeborne Bronchiectasie, Virchows Arch. f. path. Anat. **82**: 217, 1880.
11. Hart: Quoted by Romhanyi and Maccone.
12. Hope, E. W.: Industrial Hygiene and Medicine, New York, 1923, Wm. Wood & Co., p. 482.
13. Koontz, A. R.: Congenital Cysts of the Lung, Johns Hopkins Hosp. Bull. **37**: 340-361, 1925.
14. Miller, R. T., Jr.: Congenital Cystic Lung, Arch. Surg. **12**: 392-405, 1926.
15. Morlock, H. V., and Pinchin, A. J. S.: Congenital Bronchiectasis, Brit. M. J. **2**: 780, 1933.
16. Nelson, R. L.: Congenital Cystic Disease of the Lung, J. Pediat. **1**: 233-238, 1932.
17. Oechsli, W. R., and Miles, S. H.: Simultaneous Bilateral Pneumothorax, Am. Rev. Tuberc. **30**: 239-255, 1934.
18. Oudendal, A. J. F.: Ueber Epithelproliferationen und Cysten in den Lungen, Virchows Arch. f. path. Anat. **244**: 59-83, 1923.
19. Pappenheimer, A. M.: Congenital Cystic Malformation of the Lung, Proc. New York Path. Soc., New Series **12**: 193-202, 1912.
20. Parmelee, A. H., and Apfelbach, C. W.: Congenital Air Cyst of the Lung, Am. J. Dis. Child. **41**: 1380-1388, 1931.
21. Desfilis, Pascual M., and Ballester, S. Q.: Quiste gaseoso de pulmon., Cron. méd. Valencia **39**: 106, 1935.
22. Pierce, C. B., and Dirkse, P. R.: Pulmonary Pneumatocoele (Localized Alveolar or Lobular Ectasia), Radiology **28**: 651-667, 1937.
23. Robertson, A. A.: Congenital Cystic Lung, Brit. M. J. **2**: 837, 838, 1935.
24. Romhanyi, G., and Maccone, V.: Zur Pathogenese der polycystischen Lungenveränderungen, Frankfurt. Ztschr. f. Path. **50**: 442-450, 1937.
25. Sauerbruch, F.: Quoted by Ballon, Singer, and Graham.
26. Sauerbruch, F.: Die operative Behandlung der kongenitalen Bronchiektasen, Arch. f. klin. Chir. **180**: 312-320, 1934.
27. Schenck, S. G.: Diagnosis of Congenital Cystic Disease of the Lung, Arch. Int. Med. **60**: 1-21, 1937.
28. Smith, S.: Congenital Cystic Disease of the Lungs, Brit. M. J. **1**: 1005, 1925.
29. Stewart, H. L., Kennedy, P. J., and James, A. E.: Congenital Cyst of the Lung, Arch. Path. **14**: 627-636, 1932.
30. Wolman, I. J.: A Case of Congenital Cystic Lung in a Stillborn Fetus, Bull. Ayer Clin. Lab. Pennsylvania Hosp. **2**: 49-54, 1930.
31. Wood, H. G.: Congenital Cystic Disease of the Lung, J. Thoracic Surg. **6**: 634-637, 1937.

A NEW METHOD FOR DETECTION OF HIDDEN ABSCESSES

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WE HAVE been interested for about two years in the problem of the detection of hidden abscesses in the body. Not infrequently the surgeon is confronted by a patient's having a septic course, in whom he suspects the presence of an abscess and yet by no medical acumen is able to determine the site. Were the site of the lesion known, the surgeon could operate, drain, or evacuate the abscess and frequently save a life. We are reporting now a new method to detect such abscesses by the use of substances emitting gamma rays which, when injected intravenously, are accumulated in the abscessed area and, due to this radioactivity, are detected with a sensitive electron counter.

Certain phases of the mechanism of inflammation have been elaborated recently by Menkin in a series of publications.[1] He has shown that particulate matter, bacteria, foreign proteins, vital dyes, etc., when injected intravenously tend to aggregate at the site of inflammation. This localization is due to certain changes which ensue at the inflammatory area; viz., increased capillary permeability, occlusion of lymphatic vessels, the formation of fine networks of fibrin in the tissue spaces as a result of increased capillary permeability, and edema and an elevated osmotic pressure due to products of tissue disintegration. Fixation of injected material in the inflammatory region is due to phagocytosis and to the mechanical obstruction resulting from the above factors, and possibly to the physicochemical properties of the substance injected.

A recent publication by Duran-Reynals[2] showed that when a number of the newer vital dyes, T 1824, pontamine sky blue, vital new red, etc., are injected intravenously into mice having transplantable carcinomas, the dye quickly and selectively localizes in the tumor growth. The dye may be definitely detected in the cancer site within thirty minutes and the maximum intensity of staining resulted in twelve to twenty hours.

In our attempt to find a new method for the detection of hidden abscesses, we had three procedures in mind:

1. To make the abscess radio-opaque and thereby be able to detect it on the x-ray film.

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2. To make phagocytic cells in the abscess area absorb paramagnetic substances which would be localized by their properties in a highly sensitive magnetic field.

3. To make phagocytic cells in the abscess area absorb a radioactive colloid substance, the gamma radiation of which would make the abscess or tumor detectable by a suitable recording instrument.

1. It was attempted to inject intravenously colloidal silver, iron compounds, or iodized oils, which, when stored in the abscess, would render it radio-opaque.

Each of six adult rats had a suspension of infusorial earth injected into the right thigh, producing an abscess. Each rat then received a series of intraperitoneal injections of a colloidal silver preparation (choleval). At the end of two weeks these rats were sacrificed and chemical analyses revealed definite amounts of Ag in liver and spleen but none in the abscesses.

An abscess was produced in the right flank of a dog by injection of turpentine. Seventy-five minutes later colloidal iron hydroxide was injected intravenously. Two days later the dog was anesthetized and the abscess area as well as an identical area on the opposite side excised. The tissues were ashed and the iron contents determined. In the control area 0.95 mg. Fe was found and 2.05 mg. in the abscess. While there was an evident concentration of iron in the abscess, it was not considered to be of sufficient magnitude to permit detection of the abscess, nor did similar experiments reveal distinct shadows on the x-ray films. Dogs and rats with artificial abscesses received intravenous injections of thorotrast or lipiodol. When examined roentgenographically, a shadow was seen over the abscess of two animals, revealing a probable concentration of the two substances in the abscesses; in a larger series of experiments it was found, however, that the shadows were neither distinct nor constant.

We repeated in part the work of Menkin and of Reynals in another series of experiments. In large series of rats thigh abscesses were produced, some with infusorial earth and others by suspensions of *Staphylococcus aureus*, streptococcus and *B. coli* in infusorial earth; twenty-four hours later these rats were injected intravenously with various of the newer vital dyes. We found a prompt localization in the abscesses which was most striking and even small concentrations of these dyes were easily visible; e.g., 1 c.c. of 1:5,000 solution of T 1824 produced a marked staining of the skin just over the abscess.

2. This method of approach is still in abeyance because physical calculations on these magnetic substances have shown that the concentration we would have available could be observed only with extremely sensitive instruments.

3. The last method of attack on the problem seemed to us the most promising one, and the reasons were twofold. First, the Geiger-Müller electron counter is an invaluable instrument for the detection of very weak sources of radioactivity. We had observed that vital dyes were concentrated in the abscess before the reticuloendothelial system in liver, spleen, etc., took them up. If we could expect colloidal radioactive substances to behave similarly, it was thought easy to detect them and the abscess by localizing the focus of greatest emission of gamma rays with the Geiger-Müller counter. Second, we know that by means of the cyclotron we can obtain radioactive colloidal substances that are active for fairly limited periods of time—hours to days—and thereby avoid the danger inherent to natural radioactive bodies. Pending the availability of a cyclotron for our research, we have done preliminary experiments on dogs using thorium dioxide* and are now preparing to use substances activated by a radon-beryllium source.

Method and Results: The counter tube, which is generally referred to as a Geiger-Müller tube, is essentially a gas-filled diode consisting of a hollow cylindrical conductor (the cathode) mounted axially about a central conducting filament (the anode). Under the influence of an external source of penetrating radiation (which may project ionizing particles to within the "sensitive volume" of the tube, or which may effect the release of ionizing particles within that volume), the counter tube mechanism initiates a process of "collision ionization" that produces a discharge through the gas between cathode and anode. A tube of this type can respond to a single ionizing particle, and hence is a radiation detector of extreme sensitivity.[3, 4] The counter tube was so surrounded with lead metal that it was shielded for all practical purposes against gamma rays except for those entering through a small opening over which different regions of the dog were placed and counts taken.

Thorium dioxide was injected either intravenously or intra-arterially on the affected side (following the technique used by Sedgenidse and Solotuchin[5]) in dogs having thigh abscesses created by the subcutaneous injection of a suspension of staphylococcus, streptococcus or *B. coli* in infusorial earth and then we attempted to determine localization in the abscess by means of a Geiger-Müller counter. The procedure was as follows: in the late afternoon the abscess was produced; the next morning the animal was injected intra-arterially on the affected side with 5 c.c. of thorotrast. That afternoon the animal was anesthetized and the dog was passed over the tube of the counter. Determinations of five minutes' duration were made over various regions of the body; frequent basal counts were done and we routinely examined the following parts of the dog's body: head, upper chest, lower chest, abdomen, and thigh.

*Thorotrast was used.

At least three periods were taken over each of the above regions and the results then averaged. In five out of seven experiments the count over the abscess area was from one to four impulses per minute higher than the basal count; in three of these experiments this count was higher than in any other region of the body. In the other two dogs the count over the chest was higher than over the abscess itself; in these instances the thorium in the liver or in a large arterial trunk was perhaps sending gamma rays into the receiving tube. We are now conducting similar experiments on rabbits having carcinomatous foci since such regions store certain colloidal substances as effectively as do abscesses.

In conclusion we want to state that in five dogs with abscesses and intra-arterial injection of small amounts of thorium the gamma-ray counts over the abscess areas were higher than control counts and in three of the animals higher than counts over other regions of their bodies. While the number of tests does not permit statistical evaluation, yet we feel that with a relatively insensitive medium (thorium) we were able to detect five abscesses out of seven, and that with further elaboration of the method, we will be able to do much better.

At the same time we want to draw the attention of others, in laboratories better equipped for such work, to the possibilities of our research. Localization of an abscess often may be a life-saving procedure. Our results seem encouraging since thorium is a very poor source of gamma radiation and the above indicated use of compounds with artificially induced radioactivity, much more potent than thorium dioxide, should increase the number of gamma rays from even a small focus and a low concentration of the radioactive material in it.

REFERENCES

1. Menkin, V.: Studies on Inflammation. V. Mechanism of Fixation by Inflammatory Reaction, J. Exper. Med. **53**: 171-177, 1931. Isolation and Properties of the Factor Responsible for Increased Capillary Permeability in Inflammation, Proc, Soc. Exper. Biol. & Med. **36**: 164-167, 1937.
2. Duran-Reynals, F.: Localization of Foreign Proteins and Dyes in Neoplastic Growth, Proc. Soc. Exper. Biol. & Med. **36**: 369-370, 1937.
3. Weinstein, M. L., and Rovner, Leopold: The Geiger-Mueller Counter, a Recent Instrument in Medicine and Medical Research, J. Lab. & Clin. Med. **24**: 82, 1938.
4. Taft, R. B.: The Radioactivity of Thorium Dioxide Sol, J. A. M. A. **108**: 1779-1781, 1937.
5. Sedgenidse, G. A., and Solotuchin, A. S.: Über Röntgendiagnostik entzündlicher Herde im Knochengewebe mittels geringer "Thorotrast" Dosen, Fortschr. a. d. Geb. d. Röntgenstrahlen **50**: 556, 1934.

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BEZOARS AND CONCRETIONS

A Comprehensive Review of the Literature With an Analysis of 303 Collected Cases and a Presentation of 8 Additional Cases

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INTRODUCTION

THE term bezoar, as used today, is applied to concretions of various foreign or intrinsic substances found in the stomach and intestine of both men and animals. The exact origin of the term appears to be questionable and probably is lost in antiquity. However, its derivation has been attributed by most writers to the Arabian "badzehr" or to the Persian "padzahr," both of which denote counterpoison or antidote. Dechambre[1] states definitely that it is of Arabic origin, and Matas[2] has expressed this same opinion. On the other hand, Hamdi,[3] of Istanbul, claims that the word bezoar is derived from "panzehir" (antidote), which is the Turkish form of the Persian word "Pad" (anti) plus "zehr" (poison), subsequently employed by the Arabs.

The subject of bezoar forms an intensely fascinating and interesting study not only because of its relatively infrequent occurrence and its bizarre nature, but also because of the mystical lore surrounding its early development. A perusal of the literature reveals numerous recorded observations which consist primarily of sporadic case reports. However, during the past three decades a number of investigators have made intensive studies and analyzed the collected cases. In the year 1909, Wolfler and Lieblein[4] in Germany and Butterworth[5] in this country were the first to make such systematic studies. At that time the former authors were able to collect 45 cases and the latter 42 to which he added 1 of his own. Six years later Matas[6] recorded 77 cases including his own. This excellent dissertation, written in his characteristically exhaustive and inimitably perspicacious manner, remains yet a classic. In 1921 Davies[7] found that the number of recorded cases of trichobezoars had increased to 108, and seven years later Maes[8] added 8 other reported cases, bringing this total number to 116.

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In addition to his case of phytobezoar the latter collected 22 cases from the literature, thus making the total number of recorded cases of bezoars 139.[8] Although 37 cases (18 trichobezoar[3, 9-23] and 19 phytobezoar[3, 24-37]) were reported during the five-year interim between this publication (1928) and that of Kerr and Rypins[38] (1933), the latter authors stated that the total number of published cases was 139.

In a thorough search of the world literature we have been able to collect 171 cases of trichobezoars[3, 5, 7, 9-23, 38-188] and 119 cases of phytobezoar,[3, 8, 24-37, 189-250] and 13 cases of other concretions.[233, 251-262] To these we are adding 1 case of trichobezoar and 7 of phytobezoars, thus bringing the total number of recorded cases to 311, of which only 67 cases have been added since 1933.[177-188, 209-227, 246-250] A critical analysis of these collected cases and a brief report of our 8 cases form the basis of this presentation. As previously remarked by Butterworth[5] and Matas,[6] there are undoubtedly many other cases which have never been recorded, probably because they have occurred singly in the physician's experience. However, the number of reported cases serves as an index of the relative infrequency of the condition.

History.—The early conception of the origin and the magical "healing" power of the bezoar is today perhaps amusing but nevertheless historically interesting. Only a succinct archeologic résumé will be given here, and the reader desirous of a more thorough antiquarian study is referred to the excellent historical summary by Dechambre,[1] the valuable contribution of Burchard,[133] and the exhaustive and fascinating commentaries of Matas.[2, 6] Of particular interest in this regard is the historiographical excursus of Elgood[263] which contains an authentic translation from the original Persian of "A Treatise on the Bezoar Stone" from the pen of that learned Persian physician of Ispahan, Imad-ul-Din, who lived about A.D. 1520 to 1600. It would appear that, just as he was the first to present a disquisitional consideration of that newly recognized disease *atishak* or syphilis, so he was apparently the first to record a serious dissertation of this widely accepted antidote.

As early as the twelfth century B.C., the bezoar stone from the goat's stomach was known to the Hindus, a fact which is mentioned in the writings of Susruta.[133] The Persians and the Arabs were also familiar with the "healing" powers of this almost universal remedy. In fact, the impetus to its general use has been ascribed to the physicians of the Arab school. Muwaffak (923 to A.D. 77) in "Liber Fundamentorium Pharmacologiae" lists this precious stone as one of forty-four drugs derived from the animal kingdom.[133]

The first authentic account of the bezoar stone has been attributed to the Cordovan Avenzoar, twelfth century sage of Seville, who wrote the following curious myth as regards its origin: "That is the best

which is found in the east, near the eyes of stags. Great stags, in those countries, eat serpents to make them strong; and, before they have received hurt from them, run to the streams of water, and go into it so far till it comes up to their heads; this custom they have from natural instinct; and there they continue without tasting the water (for, if they should drink it they would die immediately), till their eyes begin to trickle: this liquor, which there oozes out under the eyelids, thickens and coagulates; and continues running, till it increases to the bigness of a chestnut or a nut. When these stags find the force of the poison spent, they come out of the water, and return to their usual haunts; and this substance, by degrees growing as hard as a stone, at last, by their frequent rubbing it, falls off. This is the most useful Bezoar of all.''[264, 265] This same fantastic story is related by Lonicer[266] in 1582 and almost a century later by Schurtz.[267]

The bezoar was highly prized and greatly revered as a remedy from antiquity even up to the eighteenth century. It was regarded as endowed with marvelous activities; it neutralized poisons, reanimated old age, destroyed venoms, and counteracted attacks of vertigo, epilepsy, dysentery, plague, leprosy, etc.[1, 268, 269] Worn as charms in amulets, they supposedly protected one from evils. These stones, elaborately framed in gold and bedecked with jewels, were often seen in museums. Highly valued, they were carried in the pocket or worn as an ornament on gold chains around the neck.[270] Administered internally in specific dosage, they were an antidote for poison. Moses Maimonides advocated the use of bezoar stones for pain in the gall bladder.[270] However, the indications for its administration determined the dosage. Whereas the dose ''for one bitten, poisoned, or stung, is the weight of twelve barley grains, the dose for weakness of the heart and loss of sexual power is one grain.''[263] A humorous notation in reference to the extensive use of bezoars by distinguished men is made by Oliver Wendell Holmes in the *Medical Essays:* ''Governor John Winthrop, the first, sends for East-Indian bezoar. . . . Governor Endicott sends him one he had of Mr. Humfrey.'' The author expresses the fervent hope that it was genuine ''for they cheated infamously in the matter of this concretion, which ought to come out of an animal's stomach, but the real history of which resembles what is sometimes told of modern sausages.''[271]

That the royalty who received the best available medical attention should resort to this unusual medicament is attested by its inclusion in the inventory of Queen Elizabeth's crown jewels, made at the ascension of James I: ''Also one great Bezoar stone, set in goulde that was Queen Elizabeth's, with some Unicorne's Horn, in a paper; and one other large bezoar stone, broken in pieces, delivered to our owne hands by Lord Brooke the two and twentieth day of Januarie, one thousand six hundred and twenty two.''[214] As proof of its much

extolled virtues, Nicholas Monardes writes: "And a King of England called Edward, was delivered by means thereof from a poisoned mortal wound . . . when he was almost dead. . . ."[272]

These bezoars were so highly esteemed, particularly during the Middle Ages, that counterfeits were made. Lonicer in 1582 devised some tests by which the true bezoar could be detected from the pseudobezoar: (1) A red hot needle pierced into a bezoar stone would produce no smoke. (2) Powder made from the stone would cure a poisoned man or beast. (3) The stone mixed with saliva would discolor a cloth.[266] Robinson[265] in his *Story of Medicine* says that so popular was this remedy that those who could not afford to buy them rented them by the day. So valuable were they, being even more precious than gold and silver, that according to Abdalanarack a castle in Cordova was given in exchange for one of them. Thus, Primerose, writing in 1651, states that "because the right Bezoar is seldom found, and that which wee have is sold at too deare a rate, my counsell is that it be presented only for rich men and that a large dose bee given."[273] This stone as an official remedy was admitted into the London pharmacopeias until the mid-eighteenth century, an almost incredible fact.[265]

Of the two kinds of bezoars of antiquity, the Oriental and the Occidental, Dechambre[1] says that the Oriental was the more precious. This Oriental bezoar, found chiefly in the fourth stomach and in the intestine of the bezoar goat *(Capra aegagrus)* living in Syria and Persia and of the gazelle *(Antilope dorcas)*, consists particularly of cholesterin, bile pigments, and bile salts. This combustible bezoar disperses an aromatic odor. Examination by Burchard[133] of the Oriental bezoar revealed a round- or oval-shaped mass with a smooth, almost glistening external surface. The Occidental bezoar, a product of South America, specifically from the vicuña sheep *(Auchenia vicunna)*, contains calcium and magnesium phosphate. When burned, an incombustible residue remains.

Such were the absorbingly superstitious convictions, which, veiling a surprisingly persistent sovereign remedy, have currently assumed an ubiquitous absurdity.

The first recorded authentic case of trichobezoar is credited usually to Baudamant[39] in 1779. Other cases subsequently appeared in the literature and consisted mainly of post-mortem observations.[40-50] It was not until 1883, however, that the first case of trichobezoar removed at operation was published. Stelzner,[66] in 1896, is believed to be the first to record a correct preoperative diagnosis of trichobezoar although Thornton,[52] in 1886, missed the diagnosis only by assuming that the hairball was in the transverse colon instead of the stomach.

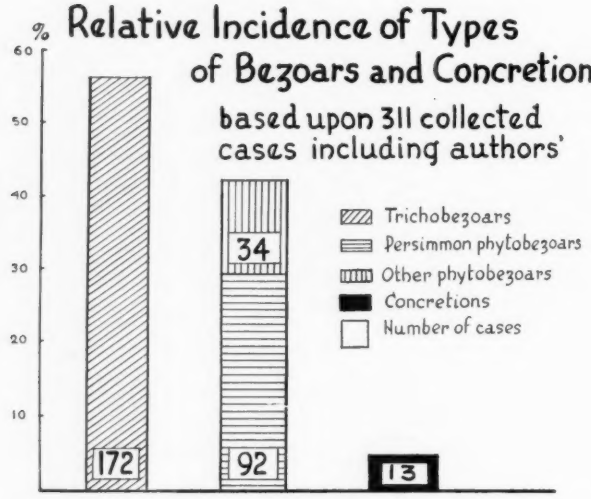
The first authentic case of phytobezoar was reported by Quain[228] in 1854. It was observed at autopsy in an epileptic dying of peritonitis

consequent to a perforated gastric ulcer. The bezoar was composed almost entirely of coconut fiber and bits of string. Langenbuch[230] and Schreiber,[232] in 1896, reported the first cases of phytobezoars removed at operation.

King[189] and Outten,[190] in 1894, are considered the first to record authentic cases of persimmon bezoars. In the case of the former the bezoar was passed while awaiting operation; whereas, in the case of the latter author, the bezoar was successfully removed surgically.

Types and Composition.—The several varieties of bezoars may be classified into the following groups depending upon the composition:

1. Trichobezoars (pilobezoars, hairballs)
2. Phytobezoars (hortorbezoars)
3. Trichophytobezoars
4. Concretions



Graph I.—Graphic representation of the relative incidence of the various types of bezoars and concretions on the basis of 311 collected cases, including those of DeBakey and Ochsner.

Of the total 311 collected cases of bezoars and concretions, including our cases, trichobezoars comprised over one-half (55.3 per cent). The phytobezoars form 40.4 per cent, there being 29.5 per cent persimmon bezoars and 10.9 per cent other phytobezoars. The incidence of concretions was only 4.1 per cent (Graph I).

The trichobezoar, as the term implies, consists of a large quantity of hair of varying lengths firmly matted together, frequently completely filling the stomach and consequently assuming its shape. Hence, they have often been referred to as hair-casts of the stomach. Whereas the general contour of these masses varies, in the majority of cases, when fully formed, they closely resemble the shape of the letter J. Our case is a characteristic example of this type (Fig. 1). Others

have described these pilous foreign bodies as crescentic or U-shaped, sausage-shaped,[73, 158] cucumber-shaped, bean-shaped,[17] kidney-shaped,[186] etc.

Varying considerably in size, depending upon the amount and duration of the ingestion of hair, they occasionally attain enormous proportions. One of the largest, reported by Davies,[7] weighed 6½ pounds immediately after removal. However, it is rather difficult to draw conclusions regarding size from the weight, as obviously this depends upon whether the mass is weighed immediately after the removal or after desiccation. For example, in d'Hauteville's case[41] the tumor

Fig. 1.—Photograph of trichobezoar removed at operation as described in Case 1. The larger intragastric part of the foreign body forms a perfect cast of the stomach. There is an extension of the hair ball into the first and second parts of the duodenum. The entire mass weighed 750 gm.

weighed 6 pounds but nineteen days later, after the specimen had dried, it weighed only 2½ pounds. Thus, the trichogenous mass reported by Russell,[48] weighing 4 pounds 7 ounces after it had dried, might be considered one of the largest. The hairball in our case weighed 750 gm., or approximately 1.6 pounds, which is about the average weight in the majority of cases. One of the smallest hairballs is reported by Pell-Ilderton;[100] it weighed 2¼ ounces dry.

Although the tumor usually consists of a single mass of hair firmly matted together, not infrequently a number of separate hairballs may be found in the same patient and occasionally are joined to each other

by faceted surfaces.[11, 39, 42, 43, 48, 57, 81, 86, 103, 110, 111, 127, 136, 159] In animals this is not an unusual occurrence[3, 116, 273] and as many as nine have been counted.[77]

The surface of these masses is usually covered with a thick coating of glairy, slimy, mucoid substance. Intimately mixed with the hair and incrusting the surface are particles of all kinds of food, especially fat which is not digested by the gastric juice. Not infrequently various other hairs besides the patient's may be observed; such as, horse's hair,[55, 57] cow's hair,[40, 68] and goat's hair.[3] Other filamentous substances occasionally mixed with the hair are cotton or wool thread and string,[18, 43, 49, 52, 57, 61, 74, 76, 91, 104, 109, 120, 123, 128, 137] bristles,[81] and vegetables and coconut fibers.[57, 139, 179]

Apparently regardless of the color of the patient's hair, the hairball usually is dark greenish-brown or black. In several instances, in spite of the fact that the patients were blondes, the hair of the trichobezoar was black.[44, 71, 94, 124, 174] This may be due to the chemical action of the gastric juice,[124] sulfides,[174] or ingested substances upon the hair over a long period of time. The extremely foul, nauseating, and putrid odor emanating from these masses is also accounted for, probably by the diuturnal fermentation, decomposition, and putrefaction of the various foods and organic residue intimately interspersed in the hair. The persistence over a long period of time of the foul odor characterizing these hairballs is illustrated in our case in which three years after its operative removal its malodor apparently had diminished very little.

Whereas the usual location of these tumors is in the stomach, not infrequently they may occur in other portions of the gastrointestinal tract. Extension of the hair bolus into the duodenum is not uncommon.[2, 23, 39, 41, 43, 49, 59, 65, 70, 76, 78, 104, 123, 155, 157] Our case clearly reveals this characteristic (Fig. 1). Although there may be slight extension into the esophagus, in only one case was the mass situated exclusively in that viscus.[60] A number of cases have been recorded in which small tufts or masses of hair have either broken off the duodenal extensions of the original tumor or become dislodged into the small intestine.[11, 34, 42, 54, 72, 86, 97, 98, 103, 122, 136, 152, 159, 171] These may occasionally produce intestinal obstruction or be passed in the stool.

Phytobezoar, as signified by the prefix of the term (Greek phyton, plant), may be composed of a variety of vegetable material including fibers, skins, seeds, leaves, roots, and stems of plants moulded together and forming a compact mass. Remnants of food particles and other organic and chemical substances, such as fats, fatty acid crystals, starch granules, muscle fibers, elastic tissue, epithelium, and salts, may be incorporated in the mass or incrusted upon its surface. Whereas phytobezoars may be composed of a heterogeneity of vegetable and plant material, the most common form is due to the ingestion of

persimmons. Of the 126 collected cases of phytobezoars, including our case, 92 (73 per cent) were of this type. Because of this fact and because of its distinctive clinical character, it is considered desirable to separate it from other phytobezoars by a more significant term. Although the appellation *Phytobezoar diospyri virginianae* has been employed for this purpose, it is objectionable because of its inexpediency and its restriction to one type of persimmon (the native American variety). For this reason we suggest the term "diospyrobezoar" from the Greek etymon, Diospyron (meaning Jove's grain), which is the generic name for the wild persimmon.[275]

The physical characteristics of the diospyrobezoar are unique and readily recognizable. They vary in shape considerably and may be approximately oval or ovoid,[214, 223] cylindrical,[25, 214] spherical,[8, 26, 36] crescentic-shaped forming a partial cast of the stomach,[214, 220] conical,[33] pearshaped,[27] or brickshaped.[24] The oblong-shaped and the pyramidal-shaped diospyrobezoars of our Cases 2 and 8 respectively illustrate the differences in contour assumed by these particular foreign bodies (Figs. 2 and 3). There is also some variation in size, but the average weight is from 1 to 200 gm., and the average dimensions are from 5 to 10 cm. in length and from 3 to 6 cm. in diameter. Upon desiccation they shrink remarkably in size and weight. This is typified by an ovalshaped specimen from one of our cases (Case 7) which immediately after removal measured approximately 14 cm. in length, 9 cm. in diameter, and weighed about 460 gm. Several weeks later, after the specimen had thoroughly dried, it measured 4 by 2½ cm. and weighed almost 60 gm. The surface may be smooth and somewhat attrite, but it is frequently irregular and bosselated or rough and pitted (Fig. 2). The color on the surface is usually dark brown or black with sometimes a greenish-yellow cast approaching lighter hues within. The mass is commonly hard to the touch, firm and compact, but it is friable and crumbles readily, very much like putty, especially after drying. There may be a sour or fermentative fruit odor. Upon section the internal structure is characteristically heterogeneous, consisting mainly of an amorphous, somewhat gummy material throughout which cellulose fibers and occasionally skins and seeds are interspersed (Fig. 4). There is no evidence of lamination, and microscopic examination reveals vegetable cells and an amorphous granular matrix. That the mass is practically all organic is demonstrated by the fact that upon burning very little ash remains.

Whereas diospyrobezoars are most commonly found in the stomach, they occur not infrequently in the small bowel. Of the 92 collected cases, including 7 of our cases, there were 72 (78.2 per cent) located in the stomach, 16 (17.3 per cent) in the intestine, and 4 (4.4 per cent) in which bezoars were observed in both. Of our 7 cases, 4 were limited to the stomach (Cases 2, 3, 7, 8), 1 to the small intestine (Case 5),

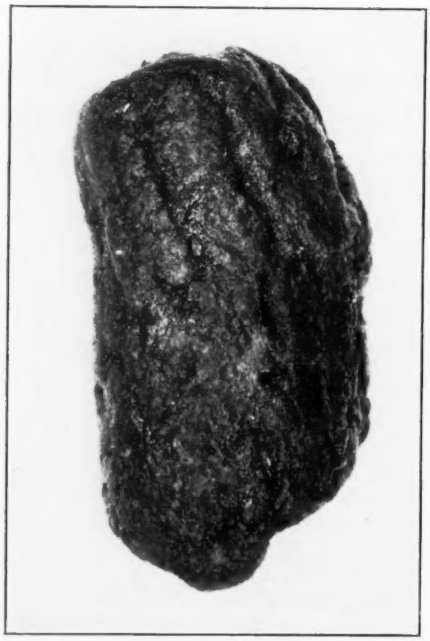


Fig. 2.—Photograph of diospyrobezoar removed at operation as described in Case 2. The surface is irregular, rough in places, attrite in others, and has a dark brown to black color. This oblong-shaped mass measured 6½ cm. by 4 cm. by 4 cm. immediately after its removal from the stomach.

Fig. 3.—Photograph of diospyrobezoar removed at operation as described in Case 8. This firm, pyramidal-shaped mass, having a dark brown color with an irregular surface, is one of two bezoars which were present in the patient's stomach.

and in 2 cases bezoars occurred in the stomach and the small bowl concomitantly (Cases 4, 6). Although diospyrobezoars usually occur singly, occasionally more than one mass may be found. This occurred in 11 of the 73 collected cases and in 3 of our 7 cases, an incidence of 17.5 per cent.[32, 37, 190, 193, 211, 214, 218, 220, 224]

Phytobezoars caused by the ingestion of vegetable material other than persimmons have been described. Indeed, the first recorded case of phytobezoar, credited to Quain[228] in 1854, consisted of coconut fibers and string. A similar case was reported by Hichens[234] and Odgers. Other vegetable substances causing such bezoars are celery fibers;[196, 240] pumpkin;[238] heather roots and twigs;[236] skins and stems of grapes,

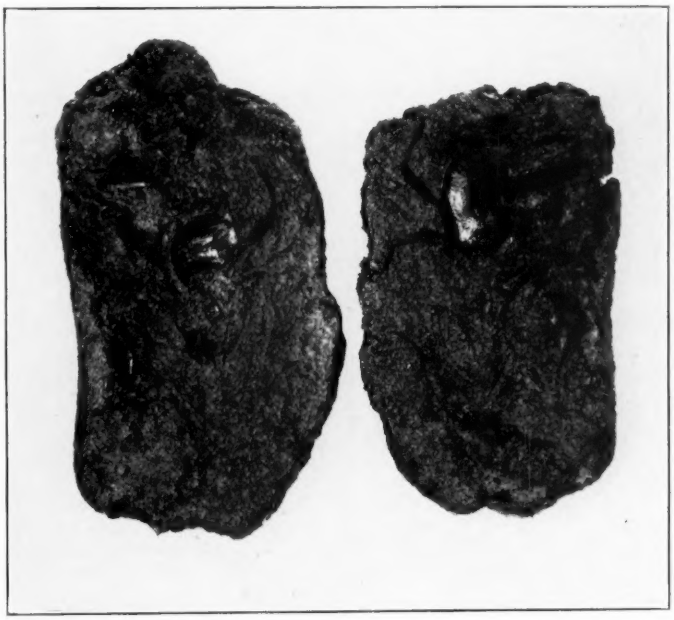


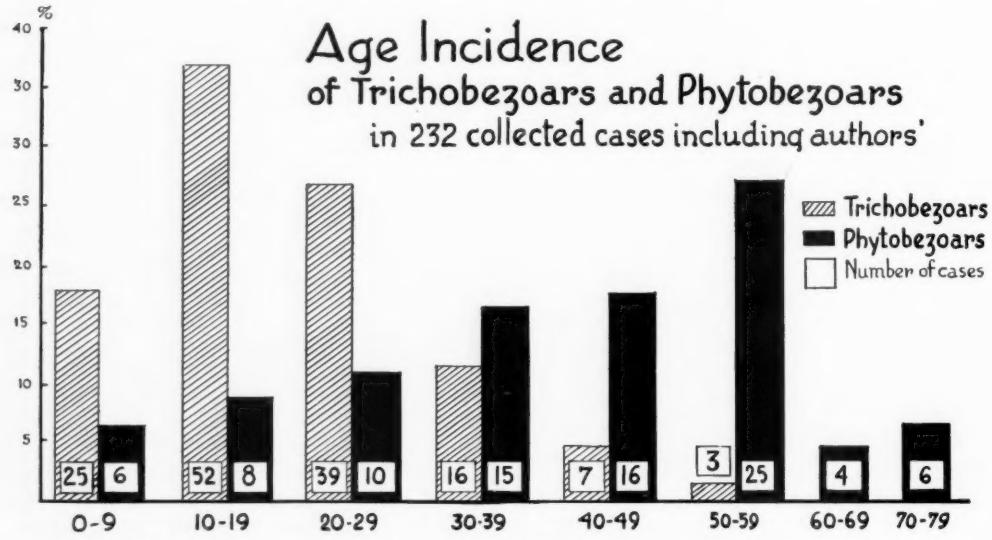
Fig. 4.—Photograph of a longitudinal section made through the diospyrobezoar shown in Fig. 2. The internal structure is characteristically heterogenous, consisting mainly of an amorphous, crumbly material throughout which cellulose fibers are interspersed. The conspicuous persimmon seed indicates the probable origin of the bezoar.

prunes, and raisins;[34, 196] "schwarzwurzel" roots, a form of salsify;[232] leek, mallow, wild beets, couch grass, and chenopodion roots;[242] "nussblatter-thee";[230, 231] and raw latex *(Ficus indica)*.[244] We have collected from the literature 34 cases of this type of bezoar. Of particular interest is the fact that such bezoars have been observed in animals.[276]

Whereas other ingested foods may become impacted in the gastrointestinal tract and produce obstruction, these cannot be accurately classified as phytobezoars because in most instances they have undergone few or no chemical or digestive changes. They should be considered preferably as food boli. A relatively large number of these cases have been recorded. The obstruction may be produced by a

wide variety of ingested foods, such as poppy seeds,[277] watermelon seeds,[278] cherry stones,[279-281] gooseberries,[282] grapes,[283, 284] figs,[285-288] orange peeling,[289-291] peaches,[292, 293] apricot,[294] beans,[295-297] potatoes,[298-302] mushrooms,[303-308] corn,[309] oats,[310] sauerkraut,[311] "ammunition" bread,[312] and bones and peanuts.[313] Further consideration of such obvious non-bezoars would be inopportune and the reader interested in this subject is referred to the excellent reviews by Eliott,[290] Caylor and Nickel,[301] and Leisinger.[314]

An unusual type of bezoar has been reported by Nathan,[315] although correct classification as such seems questionable. Because it supposedly originated at Harpanahalli, it has been given the term Harpanahalli bezoar. Consisting of a pill said to be made of the blood of a species of chameleon in combination with certain other indigenous East Indian

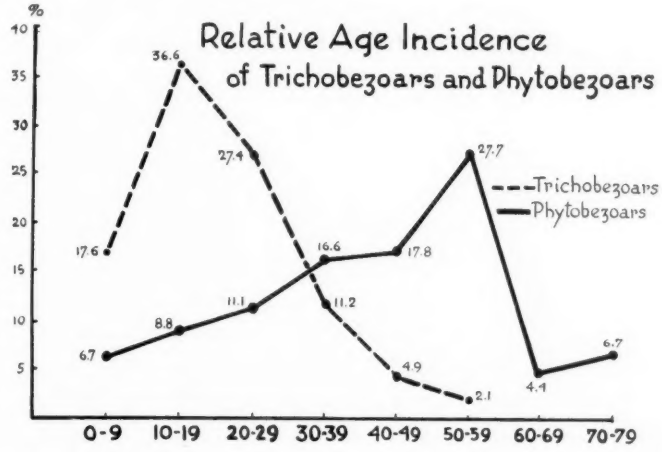


Graph II.—Graphic representation of age incidence according to decades in 232 collected cases of bezoars, including those of DeBakey and Ochsner.

drugs, about a fortnight after its administration it produces intense gastritis, severe dyspepsia, and fever. Unless treatment is instituted, the patient dies of inanition in from three to six months. Curiously enough it is not vomited or passed through the pylorus.

The concretion is an unusual form of bezoar and most commonly results from the imbibition of furniture polish by painters or furniture employees who have an insatiable craving for the polish because of its high alcoholic content, and who find it readily available by virtue of their occupation. This furniture polish consists mainly of a strong alcoholic solution of shellac and the drinking of water after its ingestion precipitates the resin into an accumulated mass. The constant repetition of this process results in the amassment of enormous concretions, weighing as much as 2,000 gm.[259] The majority of these cases

have been reported in the German literature.[251-253, 255, 256, 258, 259] A still more unusual form of concretion has been reported by Kummant.[260] This was a bezoar of pure bismuth carbonate found and removed from a woman who underwent a gastric resection for ulcer twenty-three days after the ingestion of a contrast meal of bismuth for roentgenologic examination. Another rare concretion consisting of crystallized salol found in the stomach of a Turk who came to autopsy was reported by Hamdi.[257] It was learned subsequently that he had taken large doses of salol for cystitis. Another concrement derived from medicaments has been reported by Meyer and Singer.[262] This case with peptic ulcer presented clinical manifestations of intermittent pyloric obstruction and gastrotomy revealed a firm round white mass measuring 1.5 by 1 by 1 cm. which, on analysis, was found to consist of magnesium and sodium carbonate.



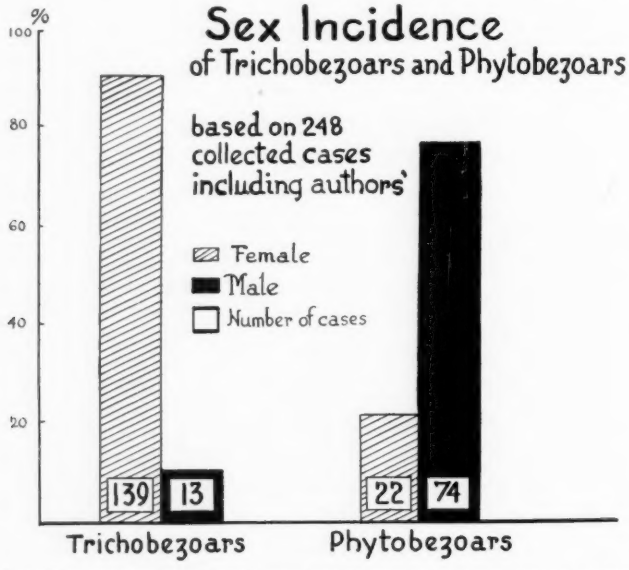
Graph III.—Comparative age incidence in 142 collected cases of trichobezoars and 90 collected cases of phytobezoars, including those of DeBakey and Ochsner.

Etiology and Pathogenesis.—Whereas age and sex are undoubtedly important factors in the development of bezoars, their exact significance has not been clearly elucidated. Of 142 collected cases of trichobezoars, including our cases, in which the age was determined, 17.6 per cent occurred in the first decade, 36.6 per cent in the second, 27.4 per cent in the third, 11.2 per cent in the fourth, and 4.9 per cent in the fifth (Graph II). Thus, over 80 per cent of the cases occurred before the age of 30 years. The youngest case was reported by Gaston[92] in an infant 1 year old and the oldest by Méreil[89] in a woman 56 years of age.

Of 90 collected cases of phytobezoars, including our cases, in which the age was determined, the age incidence according to decades was 6.7 per cent in the first, 8.8 per cent in the second, 11.1 per cent in the third, 16.6 per cent in the fourth, 17.8 per cent in the fifth, and 27.7 per cent in the sixth (Graph II). Thus, over 70 per cent of the

cases occurred after the age of 30 years. The youngest age was 3 years[191] and the oldest was 75 years, three cases having been reported with this age.[32, 220, 227] Whereas the greatest age incidence in trichobezoars was in the second decade, in phytobezoars this was in the sixth (Graph III). Although this contrary finding may be accounted for to some extent by differences in material ingested and in eating habits, a satisfactory explanation remains to be offered.

The importance of the role played by the sex factor in the development of trichobezoars is demonstrated by the fact that of 152 collected cases, including ours, in which the sex was stated, there were 139 females, an incidence of 91.4 per cent (Graph IV). On the other hand, almost the opposite is true as regards phytobezoars, for in the latter



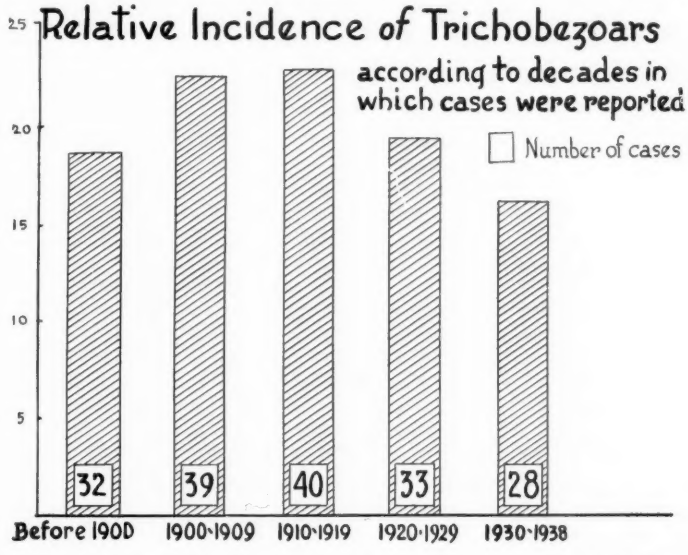
Graph IV.—Graphic representation of sex incidence in 248 collected cases of bezoars, including those of DeBakey and Ochsner.

type of 96 collected cases, including ours, only 23 per cent were females (Graph IV). This interesting observation may be accounted for possibly by differences in customs and in eating habits which predispose to the development of these respective bezoars.

However, it is rather difficult to explain satisfactorily the predominant occurrence of trichobezoars in the female sex. It is conceivable, as has been suggested by Butterworth[5] and agreed upon by Matas,[6] that this may be due to the "custom of young girls wearing their hair loose, flowing and hanging over the shoulders," which predisposes to the habit of placing strands of hair into the mouth, biting, and eventually swallowing them. Matas[6] draws the logical analogy between trichophagia and the habit of biting the fingernails, common to both sexes in early childhood and adolescence, with the former pre-

dominating in the female "solely because of the greater opportunity and temptation offered by the long hair of the girl."

Maes,[8] fourteen years later, objected to this explanation because of the currently popular custom of bobbing the hair. Obviously, if this is true, the incidence of trichobezoars should diminish markedly. This can be established with a fair degree of certitude by determining the number of cases reported according to decades. Thus, of the 172 collected cases, including ours, 32 (18.6 per cent) were recorded before 1900; 39 (22.6 per cent), during the ten-year period between 1900 and 1909; 40 (23.2 per cent), from 1910 to 1919; 33 (19.1 per cent), during 1920 to 1929; and 28 (16.2 per cent), from 1930 to date (Graph V). It can be readily observed that, whereas there has been a slight



Graph V.—Comparative incidence of 172 collected cases of trichobezoars, including those of DeBakey and Ochsner, based upon the decades in which cases were reported.

diminution in the reported incidence, it cannot be considered commensurable with the almost ubiquitous style of wearing the hair short.

The rather facetious explanation of Gull[49] and Wilks[316] must be accepted in the vein in which it probably was given. They suggested that the perverted appetite for eating hair might "depend upon some all but extinct instinct which shows itself in some lower animals. It appears that certain breeds of cats are apt to commit involuntary suicide by swallowing the hair of their coats . . ." and that "perhaps it was a relic of the feline descent of females."

Whereas some psychic or mental disturbance would appear to be an important etiologic factor in trichophagia, only 24 (13.9 per cent) of the collected cases reported demonstrated these manifestations.[11, 18, 53, 55, 60, 75, 78, 80, 83, 87, 91, 110, 116, 162, 165, 170, 173, 179, 185, 188] However, the reason for the hair-eating habit which the patients themselves

have offered seems to bear a close relation to this phenomenon. Four of the reported cases chose this unusual procedure as a method of committing suicide.[20-22, 108] Two patients[71, 113] acquired the habit in the delirium of typhoid. Among the unique and original reasons given for eating the hair are: "to clean" the tongue;[52] because the patient "liked the tickling sensation produced by the hair in its transit to the stomach";[77] to make "the voice clear";[51] and "because it was so nice."[84] It seems almost incredible that one should resort to this pernicious habit as a means of therapy for an already aggravated gastric condition, yet, Faulkner and Adams[177] report the case of a man 31 years of age who conceived this bizarre therapeutic measure of combating his illness. He would swallow the hair attached to a rope and shortly withdraw the rope, believing that this would ultimately relieve his ailment.

A few cases have been reported in which the hair-eating habit persisted or redeveloped after operation, resulting in recurrence.[160, 168, 180] Neely's[165] patient began eating hair while convalescing in the hospital after removal of a trichobezoar, and Harris'[168] patient underwent surgical intervention five times within the short period of thirteen years, each time for the removal of a hairball. Moreover, the long duration of trichophagia is further evidence of some peculiar mental derangement in these cases. The majority of these patients began the hair-eating habit early in childhood and not infrequently it has persisted for periods of ten to twenty years[2, 10, 46, 48, 65, 73, 91, 105, 147, 162, 169, 178] and even twenty-two years.[45]

Whereas no definite conclusion can be drawn from the above data, it would appear, in spite of the unconvincing statistics, that some underlying neurologic or psychiatric disturbance exists in trichophagia. Certainly hair eating cannot be considered a normal trait. Whether this is fundamentally related to various types of perverted appetites, such as bulimia, pica, or the eating of clay, dirt, or other foreign objects occasionally observed in uncinariasis, pregnancy, and in insane individuals, cannot be stated definitely. Only three cases[5, 6, 228] have been reported in which helminthiosis was an associated finding.

Apropos of this consideration of trichophagia, the following statement has been prepared by Lewis Golden,[317] of the Department of Neuropsychiatry of Tulane University: "The swallowing of human hair which leads to the formation of trichobezoar may best be understood when viewed as a 'habitual body manipulation.' Occurring, as it does, chiefly in young girls, it may be noted that there is an actual habit pattern consisting of placing the hair between the teeth, biting, and swallowing. Like other habitual body manipulations, such as nail biting, toe biting, tongue sucking, hair biting and swallowing occurs as one of the symptoms of a personality disorder. On careful investigation other expressions of personality maladjustment, such as nail

biting, enuresis, nightmares, tics, behavior disorders, or habit disorders, may be discovered. References in the literature to 'neuropathic' personality are present. Statements that trichobezoar patients were entirely normal mentally have no significance, as no mental abnormality necessarily appears in a disturbed personality, but symptoms expressing its tension, instability, and maladjustment can be discovered with proper examination.

"It is perhaps a more common expression of personality maladjustment in the adolescent girl, but has been noted in younger children. The length of the hair at that age period possibly initiates this particular manipulation. However, I have seen hair biting and swallowing in a girl with short hair whose side hairs could just be pulled to reach the mouth.

"It seems to me that the eating of various substances at times including hair in a frank psychosis is unrelated to the 'habitual body manipulation' that we have been considering.

"Its relation to Pica is less doubtful. In Pica, however, the emphasis seems to be on the perverted appetite that may vary from object to object, while in hair swallowing it is the pattern of the repetitive habitual manipulation of the hair that is to me of primary importance.

"In all three conditions, the behavior of the patient can be understood best in the light of his personality maladjustment."

There is apparently no important geographic factor, as cases have been reported from all parts of the world. Although it has been stated that very few instances of trichobezoars have been reported in the German literature, leading to the remark that the hair-eating habit "seems to be confined exclusively to English women,"[75, 11, 48] the authors have found 33 cases or approximately one-fifth of all the collected cases reported by the Germans.[15, 16, 23, 51, 56, 57, 59, 66, 68, 70, 79, 82, 83, 91, 103, 105, 106, 113-116, 118-120, 122, 131, 133, 135, 139, 143, 167, 176, 185]

Of even greater interest is the explanation for the accumulation in the stomach of ingested strands of hair. Obviously once the mass is of sufficient size to prevent passage through the pylorus, it grows by accretion; i.e., further enmeshing hair subsequently introduced. It has been assumed that the hair strands become attached and retained in the folds of the gastric mucosa, there not being sufficient friction surface for propulsion by peristaltic movements.[6, 7, 116] Subsequent additions of hair become attached and are gradually enmeshed and worked up into a ball by the gastric movements. However, the question which immediately presents itself is, why are these balls, while still small enough to pass the pyloric orifice and having now assumed sufficient surface and contour to be caught by the peristaltic movement, not transported aborally as any food or other ingested substances? That this occasionally occurs is demonstrated by the cases in which hairballs are passed in the stool[19, 63, 74, 96, 128, 132, 184] or in

which they become lodged in the small intestine. However, this fact merely intensifies the enigma because it then becomes necessary to determine why this does not occur in all the cases. To these questions only speculative responses can be made.

Curiously enough there has been a remarkable paucity of experimental investigation in this field. This is probably due to the generalized belief that the condition is rare and of little significance except as a curiosity. However, Meilchen,[116] in 1912, attempted to determine experimentally the cause of hairball formation and retention in the stomach. Using two rabbits, he forced bits of women's hair into the esophagus and daily examined the stools which he never found to contain any of the hair. Upon killing the rabbits about two weeks later the hair was found to be still in the stomach. In another series of experiments he made doughballs of women's hair and forced these into the esophagus of the rabbits. Again careful stool examination revealed no hair. Necropsies performed almost one month later revealed hairballs in the stomach, and in one animal there were a few small hairballs in the intestine and cecum. From these experiments Meilchen concluded that single bits of hair could not be moved distally by the peristaltic activity of the gastrointestinal tract. However, if the hair becomes entwined into a ball, presenting sufficient friction surface, it can be propulsed aborally.

The interesting observations of Mitchell, Bradshaw, and Carlson[318] on hairball formation in rats in relation to food consistency may be significant. They found that of 50 rats receiving paste foods made up with 25 per cent to 27 per cent fat, 45 (90 per cent) developed hairballs in the stomach. On the other hand, of 135 rats fed stock food or other diets which are dry enough to be crumbly, none developed hairballs. Similarly, rats fed on milk or cereal and milk diets were free from hairballs. The results of these experiments suggest that the pasty quality of fats may be responsible for initiating hairball formation. It is well known that trichobezoars found in humans contain fat particles, but whether this is cause or effect cannot be definitely stated. However, it would be interesting to determine the fat content of the diets of patients who develop trichobezoars.

In discussing the development of phytobezoars, it is necessary to consider them under two groups: (1) diospyrobezoars, resulting from the ingestion of persimmons; and (2) other phytobezoars due to the ingestion of a variety of other vegetable and plant matter. Izumi and co-workers[210] recently have grouped phytobezoars into a somewhat similar classification but employ a different terminology: (1) opobezoars, signifying phytobezoars composed of fruits; and (2) iniobezoars, to designate those consisting of fibrous matter.

Diospyrobezoars are undoubtedly the most common type of phytobezoars. Of 126 collected cases of phytobezoars, including ours, 92

(73 per cent) were of this type. All of our 7 cases were of this type. Whereas these bezoars are caused directly by the ingestion of persimmons, certain factors seem to be of etiologic significance; namely, age, sex, geographic distribution, and chemical content. The age and sex factors have been discussed above. Of 65 collected cases of diospyrobezoars in which the sex was stated, 53 (81.5 per cent) were males. In our 7 cases, 5 (71.4 per cent) were males. The fact that the greatest age incidence is during the sixth decade and that there is a preponderance of the male sex is rather difficult to explain. That the geographic factor obviously plays an important role in the etiology of the diospyrobezoar or persimmon ball is demonstrated by the fact that their occurrence is confined almost exclusively to certain parts of the United States and Japan. Only 1 case has been reported in Europe.[212]

The persimmon is an American Indian name of a fruit obtained from a native American tree belonging to the genus *Diospyros* of the ebony family.[275] Although there are numerous species of this fruit, the one most commonly prevalent in America is the *Diospyros virginiana*. Its natural distribution is in the states east of Kansas, Oklahoma, and Texas, and south of Iowa, Illinois, Indiana, Ohio, and Pennsylvania.[319] The fruit is a true berry, oblate to oblong in shape, which varies in diameter from 2 to 4 cm. The color of this plum-like fruit ranges from yellow to red, with most of the persimmons approaching an orange hue. Multiple seeds are characteristic and as many as eight have been found in one persimmon. The pulp of the ripe persimmon is soft, having little fiber (4.3 per cent) and sweet to the taste with an occasional slightly detectable astringent quality. Whereas several theories[26, 27, 31, 33, 196, 204, 205, 214] have been advanced to explain the development of bezoars following the ingestion of this luscious fruit, they are, in the main, highly speculative and cannot be endorsed too readily. The most plausible explanation for the mechanism of formation of diospyrobezoars has been presented by Izumi, Isida, and Iwamoto,[210] who probably have made the most extensive investigations. According to these authors, it is essentially chemical and due to the activity of gastric juice upon certain substances contained in the persimmon.

The astringency of unripe persimmons is due to the presence of soluble shibuol, a phlobatannin composed of phloraglucin and gallic acid.[320] As the fruit ripens, the shibuol coagulates, becoming insoluble and no longer astringent.[320-326] However, even in the ripe fruit traces of soluble shibuol can be detected. An important property of soluble shibuol is that it is coagulated by dilute mineral acids. According to Izumi and co-workers,[210] the gastric juice, though weak in acidity, is capable of precipitating soluble shibuol. Thus, they were able to produce experimentally artificial persimmon balls by incubating small pieces of the fruit in gastric juice. This occurred within a few hours

and with no other digestive juice, from which they conclude that the diospyrobezoar forms at one time and only in the stomach. According to these investigators, soluble shibuol remaining in the ripe fruit is present under the skin and around the calyx. Under the influence of gastric juice this chemical becomes transformed into a sticky coagulum, insoluble shibuol, which cements the pieces of skin and seeds which may be present into a ball. However, the presence of too much food matter interferes with the contact and aggregation of the fragments of the skin of the persimmon. Accordingly, an empty stomach and eating of slightly unripe persimmons or eating persimmons without peeling them predispose to the development of diospyrobezoars.

Other forms of phytobezoars have been ascribed to the ingestion of coconut fibers, celery, heather roots, skin and stems of grapes, prunes, and raisins, *schwarzwurzel*, a form of salsify, leek, mallow, wild beets, couch grass, and chenopodium roots. The mechanism of the formation of phytobezoars from these plant substances is probably essentially mechanical and depends upon the insoluble and indigestible fiber content. Hamdi,[327] in an attempt to determine their formation, rolled and kneaded these various plants and then placed them in a solution similar to gastric juice (0.1 per cent HCl and 0.2 per cent pepsin). After two days only the plant fibers remained. This applied particularly to the following plants: mallow, chenopodium, couch grass, wild beets, and *schwarzwurzel*. From this he concluded that these bezoars develop by entanglement of these fibers, probably somewhat comparable to the formation of trichobezoars. Obviously, the continuous ingestion of such substances, their improper mastication, and rapid deglutition predispose to the development of these bezoars.

Concretions may be considered as bezoars of a firmer, harder, and more solid character, and usually consist of shellac. Of the 12 collected cases, 8 (66⅔ per cent) were of this type. The formation of these concretions is essentially chemical. The patients who develop these bezoars are usually either painters or furniture employees. Because of their occupation, they have access to furniture polish, which consists mainly of a strong alcoholic solution of shellac. Following its imbibition, usually indulged in for its stimulative effect, the ingestion of water precipitates the gummy resinous contents which agglutinate into a solid mass in the stomach. The continuous repetition of this hazardous process results in the constant accumulation of more precipitate, causing the ball to grow gradually in size.

The other most frequent kind of concretion usually results from the ingestion of certain medicinal agents.[257, 260, 262] Its formation perhaps is somewhat similar to the shellac ball; that is, chiefly chemical. However, the presence of a concrement derived from this source seems to be rare in view of the numerous cases treated with these medicaments and the comparatively small number of reported concretions. The

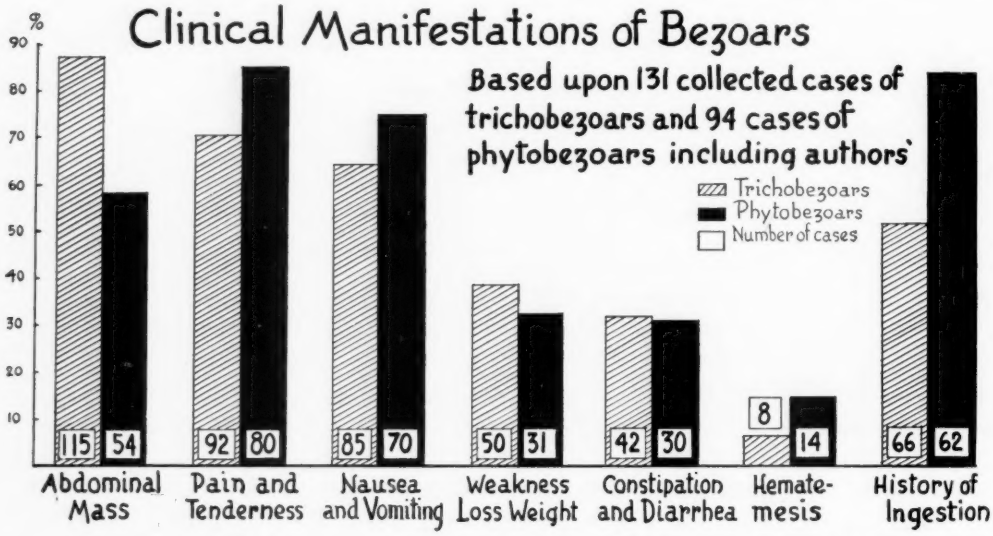
case reported by Hamdi,[257] in which a smooth, crystallized mass about the size of a hen's egg was found in the stomach of a Turk at necropsy and upon chemical analysis proved to be salol, apparently resulted from the ingestion of this drug for cystitis. The gastrolith reported by Kummant,[260] referred to above, was assumed to be due to the ingestion of a contrast meal of bismuth for roentgenologic study. Finally, the concrements observed by Meyer and Singer[262] and Fleiner[256] were considered to be due to the therapeutic administration in peptic ulcer of carbonates of magnesium and sodium in the former and bismuth in the latter.

Clinical Manifestations.—The clinical manifestations resulting from the presence of a foreign body in the stomach depend upon individual tolerance, the degree of gastric irritation, and the production of obstruction and associated lesions. Indeed, the most striking feature in the syndrome of bezoars is the fact that frequently, in spite of the presence of an enormous mass in the stomach during a long period of time, the patient's general health and vitality remain amazingly unaffected. This is observed especially in trichobezoars. Many of these patients have carried hairballs in the stomach as long as fifteen or twenty years before developing symptoms.

In general, the symptoms caused by trichobezoars begin as vague gastrointestinal disturbances for varying periods of time. This incipient stage is characterized by anorexia, dyspepsia, malaise, weakness, loss of weight, headaches, and a feeling of weighty oppression in the epigastrium. Subsequently they develop attacks of nausea, vomiting, and epigastric pain, which may be paroxysmal in character. The development of these symptoms probably corresponds with the point at which the stomach no longer can tolerate the contained growing mass plus additional ingested food. In a series of 131 collected cases of trichobezoars, including ours, abdominal pain occurred in 92 (70.2 per cent) cases; nausea and vomiting, in 85 (64.9 per cent); weakness and loss of weight, in 50 (38.1 per cent); and constipation and diarrhea, in 42 (32 per cent) (Graph VI). Not infrequently few or no symptoms referable to the stomach are observed. However, that this should occur is not inconceivable, for the sievelike character of the mass probably permits the seepage of liquids and food particles through the meshes, and foods also trickle over and around the mass, as is clearly demonstrated by the characteristic fluoroscopic picture. The pain varies considerably in character from a slight epigastric discomfort, a constant gnawing or dull ache, to severe and violent colicky pain. There is usually no characteristic relationship to meals, although in a number of cases the pain was aggravated by ingestion of food. Many of the patients complained only of anorexia and nausea, but in most of these cases there was associated vomiting.

Whereas some vomited everything ingested, others were able to tolerate liquids. Loss of weight and weakness usually became manifest in these cases if the condition was allowed to progress. Although bowel disturbances did not occur in many of the cases, almost one-third complained of constipation or diarrhea, which in the majority of instances was alternating in character.

Various other inconstant symptoms, depending upon individual differences, have been observed. Hematemesis was reported in only eight of the collected cases, an incidence of 6.1 per cent (Graph VI). This undoubtedly results from associated traumatic lesions, such as mucosal irritation, denudation, or ulceration. Headaches and insomnia are also rare complaints. As the condition progresses and



Graph VI.—Graphic representation of the characteristic clinical manifestations of bezoars based upon 225 collected cases, including those of DeBakey and Ochsner. The incidence of the history of ingestion is based upon 74 collected cases of diospyrobezoars, including the cases reported by DeBakey and Ochsner.

complications, such as ulceration, perforation, peritonitis, and intestinal obstruction, develop, the clinical picture assumes corresponding changes.

The physical findings in the early and uncomplicated stage usually are not characteristic. The patient may appear in fairly good general health, although not uncommonly they seem undernourished, pale, fretty, and restless. Whereas the patient who suffers an acute attack may develop fever, particularly if complications occur, in general the temperature, pulse, and respiration remain normal. The breath may be foul, the tongue may appear furred, and the hair may be somewhat deficient, especially in the frontal and temporal regions. Frequently an abdominal tumor associated with some tenderness is the only abnormal sign. Of 131 collected cases, including ours, a palpable abdominal mass was present in 115 (87.7 per cent) (Graph VI). Among

the distinguishing features of this tumor are its unusual range of mobility, its well-defined, smooth outer surface, and its uniform firmness. Although the tumors apparently assume no characteristic form, they have been described most frequently as crescentic or J-shaped, and more rarely as sausage-shaped, cucumber-shaped, bean-shaped, kidney-shaped, and spherical. Most frequently located in the epigastrium and occasionally extending from one hypochondrium to the other, they sometimes occupy much lower positions. Whereas tenderness is not a prominent manifestation, it is not an infrequent occurrence, particularly in the more advanced cases. Crepitation is rarely elicited on palpation.[104, 138]

The symptom complex of phytobezoar, particularly diospyrobezoars, is slightly different. The patient usually recounts that his complaints began soon after engorging himself upon persimmons. Not infrequently he was hunting, fishing, or walking through the woods or field and found a persimmon tree with its succulent fruit, which he devoured to appease his hunger. Following this a liberal quantity of water was imbibed to satisfy an insatiable thirst. Within a few hours to a few days following this refreshing but insalubrious repast, characteristically an acute gastrointestinal disturbance of varying intensity develops. In the more severe cases this is manifested by violent nausea and vomiting, intense cramping epigastric pain, marked diarrhea followed by obstipation, and occasionally some fever. Others, less severely affected, may complain merely of slight nausea and a sense of discomfort or heaviness in the epigastrium with alternating mild diarrhea and constipation. Usually the patient is fairly comfortable for varying periods of days to weeks following the subsidence of the acute attack. However, most commonly there is not a complete return to normal. Recurrent attacks of a milder character occur between varying intervals of almost complete relief. Epigastric discomfort and even pain, which may or may not be related to the ingestion of food, frequently occur. Unless the history of this characteristic initial attack is obtained, the clinical picture subsequently observed is most confusing and may readily resemble almost any intra-abdominal disturbance. Thus, in the milder forms the patient is not likely to attribute his illness to the ingestion of the fruit and may not even recall the incident. However, close questioning will elicit this characteristic history in the great majority of cases. This is clearly demonstrated by the fact that of 74 collected cases of diospyrobezoars, including ours, 62 gave this history, an incidence of 83.7 per cent (Graph VI). That epigastric pain, nausea and vomiting, weakness and loss of weight, and constipation and diarrhea are the most constant symptoms is shown in the collected cases of phytobezoars including ours by the following respective incidences: 85.1 per cent, 74.4 per cent, 32.9 per cent, and 31.9 per cent (Graph VI). More rarely

hematemesis and even melena may be observed. Hematemesis occurred in 14 (14.8 per cent) of the collected cases (Graph VI). This is found more frequently in the complicated cases with ulceration, as is indicated by the closely corresponding incidence, 19 per cent, of this complication in phytobezoars. The clinical manifestations of phytobezoars other than diospyrobezoars are in general similar to those of the latter, with the exception of the characteristic initial acute attack and the history of persimmon ingestion.

The physical findings in phytobezoars are astonishingly few in most cases. The patient appears to be in fairly good health, and only in the more advanced and complicated cases is there undernourishment and apparent loss of vigor. The temperature, pulse, and respiration usually are normal. Probably the most constant findings are the presence of an abdominal mass, some tenderness, and possibly slight rigidity. Of the 94 collected cases of phytobezoars including ours, an abdominal mass could be detected in 54 (57.4 per cent) (Graph VI). It will be observed that, whereas the mass was palpable in 87.7 per cent of the collected cases of trichobezoars, it was felt in only 57.4 per cent of the collected cases of phytobezoars. This discrepancy is undoubtedly explained by the correspondingly greater size of trichobezoars. Among the distinguishing features of the mass are its free mobility, its spontaneous displacement, its facile disappearance, its well-defined contour, and its almost bony firmness. It is most frequently found in the epigastrium, although it may appear under the left costal margin; it may shift to the right hypochondrium, and has been observed in much lower positions. Varying in size from that of a walnut[216] to that of two fists,[209] it has been described as ovoid, spherical, crescentic, or oblong in shape. Whereas there is usually some associated tenderness, this is not a prominent manifestation, except in the more advanced cases.

The symptoms and signs of concretions are in general somewhat similar to phytobezoars except, of course, there is absence of the characteristic history of the ingestion of persimmons or plant material. However, in the cases of shellac concretions there may be a history of furniture polish imbibition and employment as a painter or a furniture worker. Not infrequently there is suggestive manifestation of intermittent pyloric obstruction.

Laboratory Examination.—The routine laboratory studies in trichobezoar usually reveal slight secondary anemia and a mild leucocytosis. The hemoglobin may vary from normal[120, 147] to as low as 15 per cent.[5] However, in the majority of cases it is somewhat lower than normal as is shown by the fact that the average figure in the collected cases, including ours in which this examination was recorded, was 62 per cent. The red cell count varied from 2,764,000[153] to 5,300,000;[138] whereas, the average count was 4,268,000. The lowest leucocyte count reported

was 950;[22] the highest, 21,700;[13] and the average was found to be 12,813. The lowest polymorphonuclear percentage was 55;[141] the highest, 90;[13] and the average was 74.4 per cent.

The results of blood studies made in the cases of phytobezoar are surprisingly similar, being only slightly higher. The lowest figure for the hemoglobin determination was 33;[227] the highest, 100;[43] and the average, 68.4 per cent. Corresponding estimations of the red cell count were respectively 2,600,000,[209] 5,152,000,[30] and 4,014,328. The lowest white cell count was 5,600;[226] the highest, 14,200;[209] and the average, 10,126. The polymorphonuclear percentage varied between 66[212] and and 92,[214] but the average was 77.6. Obviously these estimations will vary considerably with the presence and extent of complications. There is no reason to expect remarkable changes in the uncomplicated cases.

The gastric analysis and stool examinations sometimes reveal significant findings, particularly in trichobezoars. Gastric analysis in these cases usually reveals a normal or low acidity as exemplified by our case (Case 1) in which the total acidity was 28 and the free HCl was 4. This is probably explained by the development of a chronic gastritis consequent to the constant irritation, trauma, and stasis produced by the foreign body over a long period of time. However, high acid values occasionally are observed, as in the case of Ormai,[176] in which the total acidity was 96 and the free HCl was 70. Bits of hair may be found sometimes in the gastric contents as well as blood and particles of fats, starches, and other food detritus. Stool examination may also significantly reveal hair.[15, 19, 52, 63, 74, 91, 96, 104, 120, 128, 132, 184, 187]

The gastric analysis in cases of phytobezoars reveals somewhat different findings. Whereas the gastric acidity may vary considerably, in the main there is a tendency toward high acid values. Thus, the lowest total acidity and free HCl were respectively 33 and 11[24] and the highest estimates were respectively 112 and 92.[196] In a series of 16 collected cases including ours in which these determinations were made, the average figures were found to be 41 for the free HCl and 62 for the total acidity. It would appear, therefore, that patients with phytobezoars have a tendency toward high gastric acidity. Whether this is cause or effect cannot be definitely stated, but it might be inferred that this is an etiologic factor, especially in view of the fact that the shibuol coagulates in the presence of dilute mineral acids. However, the gastric hypersecretion may be explained readily on the basis of gastric irritation by the foreign body. Thus, previous to the development of the foreign body, the gastric secretion may have been perfectly normal. Since the gastric analyses on all the reported cases were made after the development of the foreign body, it is fallacious to reason that hypersecretion is an etiologic factor, but more rational physiologically to explain the high acid values on the basis of effect.

Roentgenography.—Undoubtedly one of the most important and reliable aids in the diagnosis of bezoars is roentgenography. The value of this laboratory procedure is strongly emphasized by the fact that, whereas of the 44 collected cases of trichobezoars reported by Matas, in 1914, prior to the advent of systematic roentgenologic examinations, only 10 (22.7 per cent) were correctly diagnosed preoperatively, of 41 cases in which roentgenographic examinations were performed, 30 (73.1 per cent) were correctly diagnosed preoperatively. Of 50 collected cases of phytobezoars, including ours, 34 (68 per cent) were correctly diagnosed preoperatively.

It was not until 1911 that attention was directed to the diagnostic significance of roentgenologic study in cases of trichobezoar by Kampmann[115] and Clairmont and Haudek.[114] Whereas Kampmann suspected the diagnosis from the history and the presence of hair in the stools in a girl with a palpable epigastric tumor, he emphasized the value of roentgenographic examination after a barium meal which clearly demonstrated the intragastric character of the tumor. The radiologic aspects of trichobezoars were especially stressed by Clairmont and Haudek.[114] Other notable contributions in this regard soon followed by Huttenbach,[120] Francke,[119] Schwartz,[131] Burchard,[133] and Hausmann.[135] However, Ramsbottom and Barclay[130] and Holland[127] deserve especial credit for emphasizing and describing the proper interpretation of the roentgenographic characteristics of these tumors. The former authors, in describing the fluoroscopic examinations, state that the bismuth meal flows into the stomach first along the greater curvature, then extends along the lesser curvature, and by manipulation and rotation of the patient the bismuth is seen being displaced by the mass actually within the stomach. By palpation the tumor is shown to be freely movable within the stomach and the top of it could be displaced above the level of the bismuth and into the clear air space in the fundus of the stomach. Holland,[127] with a "vivid recollection" of the first case he observed in 1913, made a definite preoperative diagnosis on another case the following year. His classic description of the roentgenographic characteristics of this case are worth repeating:

"1. Before any food was given it was possible to make out the general shape of the tumor on the screen, and to differentiate it from the liver, as it was thrown into relief by the gas-distended transverse colon. A plate was taken which clearly showed this.

"2. The first few mouthfuls of a liquid barium meal remained held up in the cardiac end of the stomach, and spread out as if forming a cap to something inside the organ.

"3. Shortly after swallowing a breakfastcupful of the food the whole stomach was mapped out by what was obviously the barium lying between the walls of the stomach and the mass filling it."

A number of other observers have since directed attention to these roentgenographic characteristics. Our case (Case 1) is a typical example. The fluoroscopic examination is performed best with the patient in the erect position. As barium enters the cardia, it is observed to hesitate or be suspended for a few seconds in the upper region of the fundus. Then suddenly it trickles or diffuses slowly downward on either side of a nonopaque foreign body, following the regular contours of the greater and lesser curvatures. Streaks or bands of barium then rapidly extend down, fuse, and finally reveal the entire stomach normal in con-

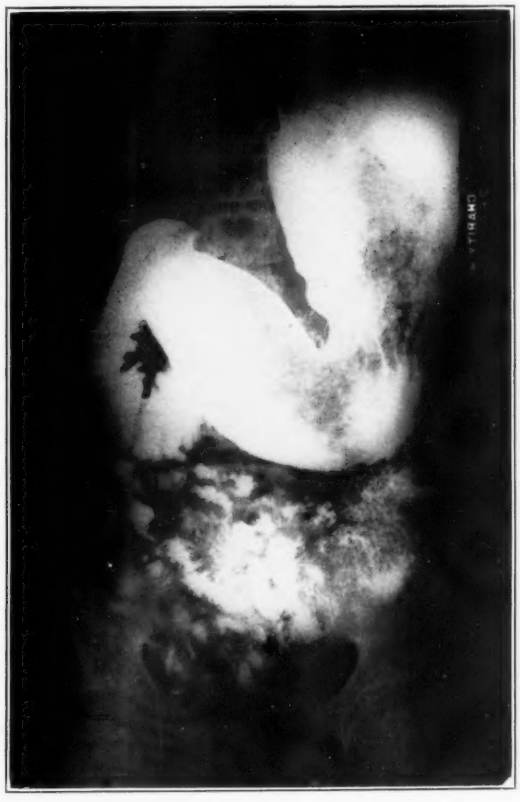


Fig. 5.—Anteroposterior roentgenogram of patient's stomach made after ingestion of barium meal as described in Case 1. The large defect in the gastric shadow extending almost throughout the entire distended stomach with no irregularity in contour is characteristic of trichobezoar.

tour but apparently increased in size. The barium gradually collects in the antrum and pyloric part of the stomach, giving a denser appearance in this region as well as along the greater and lesser curvatures (Fig. 5). Usually there is no evidence of peristalsis. In those cases in which a fluid level is observed with a gas bubble above it, it is possible by palpation to displace the foreign body above the fluid level appearing as a round mass streaked with barium and projecting into the less opaque air bubble. At the end of six hours most of the barium has left the stomach, but frequently a sufficient amount has remained attached

to the mass to outline the stomach.[328] These flecklike bands or streaks of barium may be observed extending into the duodenum indicating the

Fig. 7.

Fig. 6.

Fig. 6.—Anteroposterior roentgenogram of stomach of patient described in Case 3 following ingestion of barium meal. The defect in the barium shadow is caused by the intragastric diospyrobezoar.

Fig. 7.—Anteroposterior roentgenogram of stomach immediately following ingestion of barium meal as described in Case 8. This was made on patient's second admission to hospital. The defect in the barium shadow clearly outlines the intragastric foreign body in the prepyloric region.

projection of the hairball into this organ. It is also possible to demonstrate roentgenologically the intragastric character of the foreign body by insufflating the stomach. The mass then becomes opaque in contrast to the air.

Fig. 8.

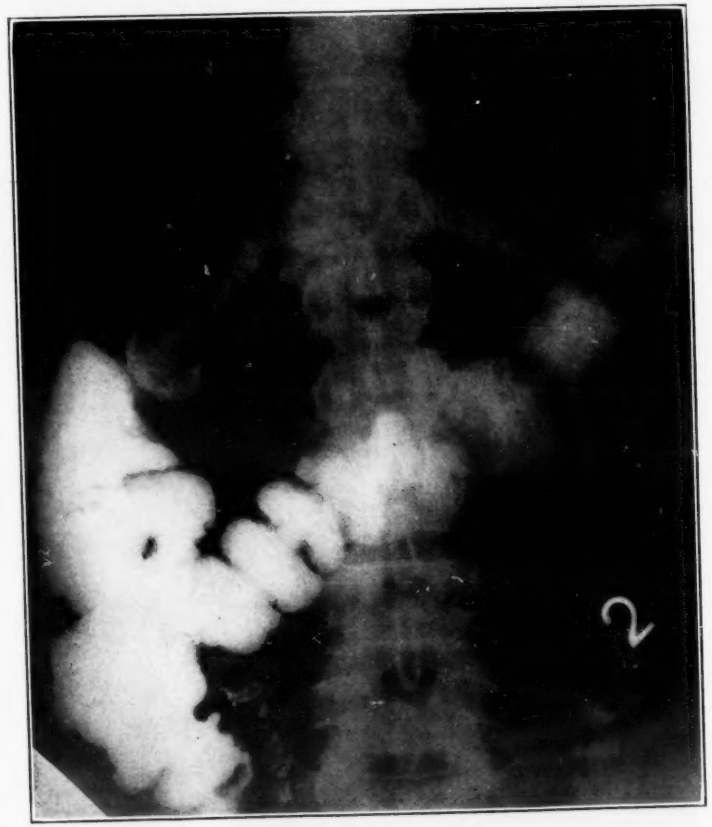


Fig. 9.

Fig. 8.—Anteroposterior roentgenogram of stomach following ingestion of barium meal as described in Case 7. The barium completely fills the antral region of the stomach and above this the mottled transradiant area in the fundus clearly demonstrates the foreign body.

Fig. 9.—Anteroposterior roentgenogram of stomach of patient described in Case 8, made twenty-four hours following ingestion of barium. Adherent flecks of barium clearly reveal the mass in the stomach as a reticulated or mottled transradiant area in the prepyloric region. Compare this with Fig. 7.

Fig. 10.

Fig. 11.

Fig. 10.—Anteroposterior roentgenogram of stomach of patient following ingestion of barium meal, as described in Case 8. This was made on patient's first admission to hospital. There are two negative shadows, one in the fundus and one in the prepyloric region, suggesting the presence of two intragastric foreign bodies.

Fig. 11.—Anteroposterior roentgenogram of stomach of patient following ingestion of barium meal as described in Case 6. Two separate round negative shadows are observed in the prepyloric and lower fundic regions of the stomach and indicate the presence of two intragastric foreign bodies.

Diospyrobezoars and other phytobezoars also have characteristic roentgenologic appearances. Fluoroscopically, with the patient in the erect position, the barium is observed flowing freely into the fundus of the stomach and then, as it enters the pars media, it appears to split around a nonopaque body into two columns which join farther towards the pylorus. The entire mass rapidly becomes coated with barium but gives a less dense appearance than the barium in the remainder of the stomach (Figs. 6 and 7). By palpation the intragastric mass can be readily pushed up into the fundus of the stomach (Fig. 8). The free mobility of this intragastric mass also can be demonstrated easily by having the patient assume different positions. Peristalsis is usually observed, although sometimes it is rather feeble. Even at the end of six, twelve, or twenty-four hours when the stomach is empty of the meal, adherent flecks of barium clearly reveal the mass in the stomach as a reticulated or mottled transradiant area[329] (Fig. 9). Occasionally two separate masses having this appearance can be observed as in one of our cases (Figs. 10 and 11). These mottled, less dense areas are distinctly visible, one appearing in the fundus and another in the prepyloric region.

(To be continued in the January issue. The references will accompany the second section.)

Review of Recent Meetings

REVIEW OF THE THIRTY-NINTH ANNUAL MEETING OF THE AMERICAN ROENTGEN RAY SOCIETY, ATLANTIC CITY, N. J., SEPT. 20-23, 1938

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(From the Department of Radiology, University of Minnesota)

A NUMBER of papers of interest to the surgeon were presented at the annual meeting of the American Roentgen Ray Society.

Robert E. Fricke, of the Mayo Clinic, reported on results obtained in a series of thirty-five cases of Peyronie's disease (fibrous plagues of the penis). The treatment used was radium plaques, with heavy filtration (2 mm. lead plus 1.5 mm. "monel" metal). Approximately 6/7 erythema dose was given per treatment. The best results were obtained in cases receiving two or three treatments. Cures were reported in 19.3 per cent of the cases; improvement was noted in 32.3 per cent; in 48.4 per cent no improvement was noted. Most beneficial results were noted in cases of short duration (six months). Discussant **Charles A. Waters,** Baltimore, Md., indicated these results were superior to those of surgery.

William A. Evans and **Traian Leucutia,** Detroit, Mich., reported on statistical results of a fifteen-year follow-up study of 172 cases of mammary carcinoma treated between 1922 and 1924, as well as a group of 1,200 cases treated between 1922 and 1937. Interesting observations on the fifteen-year follow-up were: Local recurrences were not infrequently observed in Group I cases (local carcinoma, confined to breast, with no axillary metastasis) which had been treated by a combination of surgery and irradiation, as late as twelve to fifteen years after treatment. The authors suggested the term "carcinoma cure" should probably be replaced by "carcinoma survival." In the group 51 cases were well at 5 years; 16 died from carcinoma in the period from 6 to 15 years; 11 died from causes other than carcinoma, leaving 24 cases alive at 15 years.

The later group of 1,200 cases was divided into three groups: (A) those in which irradiation and surgery were used; (B) irradiation alone; (C) recurrent cases following surgery in which irradiation was used later. Each group was subdivided into five groups based on the stage of clinical extension. Survivals for each subdivision were given. There was a 30 per cent five-year survival, including both operable and inoperable groups and a 21 per cent ten-year survival. A definite increase in the percentage of recurrences was noted shortly after the year 1927, at which time roentgen irradiation was temporarily discontinued. In contradistinction to other types of carcinoma the tumors in the younger age group did not appear to be more malignant than in the older age group. Sterilization was of no proved value in this series.

Received for publication, October 6, 1938.

Edwin A. Merritt, R. R. Rathbone and **Ralph M. Caulk,** Washington, D. C., presented a method of direct irradiation of the cervix and of intraoral lesions, without interposition of soft tissue parts. A simple attachment to the high voltage apparatus, with a series of copper tubes of different sizes, provides the necessary apparatus. A Ferguson speculum and obturator are used for distending the vaginal cavity. Total divided dosage of from 7,000 to 8,000 r can be given to the cervix with no discomfort to the patient. This method alone is used in Stages I and II, while in Stages III and IV the routine pelvic irradiation with radium application is used. Carcinomas of the tonsil, uvula, and alveoli have been treated in the same way without much discomfort to the patient. The results are superior to previous methods used.

Charles L. Martin, Dallas, Tex., described a method of treating metastatic cervical nodes which combines x-irradiation and radium implantation, neither of which, when used alone, previously has given satisfactory results. In reviewing former methods of treatment of epidermoid metastatic cervical nodes, a survey of different authors indicated a 2 to 1 choice of the following procedure: block dissection if nodes are palpable; no block dissection if nodes are not palpable. Martin implants gold seeds directly into and around the individual nodes and follows with early irradiation up to 2,100 r over a 15 by 15 cm. area in from seven to eight days. A severe skin reaction results, which later subsides. The method has produced encouraging results.

Fred M. Hodges, Richmond, Va., presented a paper on roentgen therapy of hygroma cysticum colli in children. This entity previously has been treated entirely by surgery, but results have not been encouraging because of the inability to remove all the involved tissues and a high mortality from infection. Treatment (100 r.) monthly, for a period of about six months, has produced almost complete disappearance of the growth, while follow-up studies indicate no late harmful effects. Treatment should be given early and when growth is rapid. Thin-walled, predominately cystic lesions are best treated by surgery.

Karl Kornblum, Philadelphia, Pa., pointed out that the possibility of a complicating carcinoma must always be excluded in achalasia (cardiospasm). While not a common complication, this diagnosis is easily overlooked because first, the picture usually is so striking that no thought is given to carcinoma, and second, retained food and barium may obscure the lesion. Two cases of carcinoma complicating achalasia and one in which a malignancy simulated an achalasia were reported.

Three cases of lymphosarcoma of the stomach were presented by **Vincent W. Archer,** of the University of Virginia. All were treated by x-irradiation; one patient is well after six years, while two have been followed for eighteen months. The presenting symptoms and roentgen findings in all three cases were gastric ulceration. The ulcers are often large; the masses usually feel softer at surgery than those of carcinomas. Irradiation offers as much hope, or more, than surgery. Frozen sections should be obtained more often and, if lymphosarcoma is present, no further surgery should be done as it offers so little hope of cure. There were thirteen five-year remissions out of about ninety cases reported to the authors in a survey recently conducted.

James E. Lofstrom and **R. J. Noer,** Detroit, Mich., presented a unique method for localizing lesions of the small intestine. This method employs intestinal intubation with a Miller-Abbot tube to which Wangensteen's method of suction is

applied. The intubation apparatus consists of a double tube; to the distal end of one is attached the ordinary metal tip. The second tube, which is combined with the first, terminates in a small, heavy rubber condom, about two or three inches proximal to the distal end of the first tube. The balloon may be readily distended, when in the stomach or intestine, and the increased peristaltic activity produced by the presence of the distended balloon results in rapid progress of the metal tip of the tube to the site of obstruction. It appears that this balloon practically obviates any delay in passage of the tube, either in the stomach or bowel. The authors now inject a small amount of barium through the first tube, which greatly facilitates exact localization and study of the obstructing lesion. Because of the suction feature, the confusion resulting from overlying gas-distended loops is obviated. No danger results from the barium injected, because only a small amount is needed (due to decompression) and the contrast material may be readily aspirated following roentgen ray examination. A double-contrast study is easily made by simply injecting air following the barium injection. In occasional cases the distended balloon tends to relieve the obstruction itself, especially if adhesions or bands are a factor in its production. The advantages of Wangensteen's method of decompression are at the same time available, since continuous suction may be applied. Several excellent exact localizations of obstructions were demonstrated by the authors.

Cinefluorographic studies of the chest in normal, diseased, and surgical conditions, especially pneumothorax and thoracoplasty, were shown by **William H. Stewart** and **Francis H. Ghiselin,** New York, N. Y. Their "moving picture films" showed beautiful demonstrations of paradoxical movement of the diaphragm and of mediastinal shift and fixation.

Benjamin Castleman and **Aubrey O. Hampton,** Boston, Mass., presented a very interesting study of correlation of post-mortem chest teleroentgenograms with autopsy findings. As a result of their studies, unusually interesting features of pulmonary embolism and infarction were presented. Shortly after death, the cadaver is suspended by a neck harness attached to a pulley. Excellent roentgenograms at a distance of seven feet are then obtainable, after which the lungs and heart are very carefully removed and prepared in such a manner that most exacting pathologic correlations can be made. It was shown that pulmonary congestion is not necessarily a prerequisite for infarction and that this condition is far more common than was formerly believed. Likewise, a much higher incidence in nonsurgical patients than has been expected was shown. For instance, 30 per cent of their cases of embolism and infarction occurred in medical noncardiac patients. The pathologic study indicates that many of the so-called linear areas of atelectasis, as shown on the x-ray film, are really areas of infarction in a healing stage. These areas may disappear after varying intervals of time and may easily be overlooked at post-mortem examination. Nodular areas of thickening at the ends of the linear densities are often seen in infarction. The failure to obtain roentgen studies shortly before death, as is so often necessarily the case, probably accounts for previous misconceptions regarding the incidence of infarction.

One of the most sensational studies presented at the meeting was that of **George P. Robb** and **Israel Steinberg,** New York, N. Y., who have demonstrated the various chambers of the heart, the pulmonary circulation, and the great vessels by means of rapid intravenous injection of a 70 per cent solution of diodrast (35 c.c.). Films made at 1 and 1½ seconds after beginning of the injection demonstrate the basilic or cephalic vein, axillary, subclavian and innominate veins,

and superior vena cava and right auricle. At 3 to 5 seconds the right ventricle, pulmonary artery, and branches are shown, and a few seconds later the pulmonary veins, left auricle, ventricle, aortic cusps, and aorta are shown. Obstruction and collateral circulation of the left innominate vein was demonstrated in cases of mediastinal tumors, deformity of the superior vena cava in cases of hilar glandular enlargement, and displacement or deformity of the pulmonary arteries in bronchiectasis were well shown. Good visualization of rotation of the heart and vascular structures was demonstrated in a case of marked fibrothorax secondary to bronchiectasis, although the ordinary posteroanterior film of the chest failed to reveal the identity of the structures. The vascular patterns are also well demonstrated in cases of pulmonary abnormalities secondary to bronchogenic carcinoma, pneumothorax, silicosis, and pulmonary fibrosis with emphysema. Dilatations and saccular aneurysms of the aorta can be very effectively localized. No consequential ill-effects on the patients have been encountered. The technique is very exacting and requires considerable preparation of both patient and apparatus.

Correspondence

To the Editors:

In the September number of SURGERY there is an excellent paper on subphrenic abscess, with a report of 59 cases studied by Doidge and Warner. While x-ray as a means of diagnosis is mentioned, I can find no reference to pneumoperitoneum artificially induced. The method is so important that no excuse is made for the present note. Those who may be interested in the matter will find it discussed and illustrated in *Thoracic Surgery* (Lilienthal: Philadelphia, 1925, W. B. Saunders Company) Vol. 1, page 603.

Air or gas will not be demonstrated between the liver and the diaphragm except when there has been injury of a gas-containing viscus, such as the stomach, intestine, or common bile duct, or in the case of intraperitoneal gas bacillus infection in suspected cases. If on usual roentgenologic examination in the upright or lateral-recumbent position no gas is seen, pneumoperitoneum should be induced with oxygen through a fine needle puncture in the left lower abdomen. Exposures of the same kind as those previously made will then almost certainly demonstrate subphrenic transparency in the negative cases. The exposure with the patient lying on his left side and radiographed anteroposterior or posteroanterior will give a very striking picture; especially in the cases with no subphrenic abscess and with no liver adhesions.

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